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MANUAL

FOR

SUBMARINE MINING

1912

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MANUAL FOR SUBMARINE MINING

EDITION OF 1912

R. W. PINGER.
2nd Lieut. Coast Artillery Corps.
U. S. War Dept. General Staff.

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This Manual for Submarine Mining, revised to 1912, is approved and published for the confidential information and guidance of the Army of the United States. Under no circumstances shall its contents be divulged to persons not in the military or naval service of the United States.

By order of the Secretary of War:

Wm. H. Carter,
Major General, Acting Chief of Staff.

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CHAPTER I.

DEFINITIONS AND GENERAL PRINCIPLES.

A submarine mine consists of an explosive charge inclosed in a water-tight case, and a firing device, the whole intended to be submerged in a waterway which it is desired to close against the passage of an enemy's vessels.

With respect to the position of the case containing the explosive, submarine mines are of two classes, buoyant and ground.

In the buoyant mine, the case contains the explosive and the firing device, and has such excess of buoyancy that it would float were it not held below the surface by a mooring rope and an anchor. The submergence is such that, while the mine would be struck by the hull of a passing vessel, it is not so near the surface as to be seen.

Buoyant mines may be planted and operated successfully in water 150 feet deep. They should not, in general, be used where the depth of water is less than 20 feet.

In the ground mine, the case contains the explosive and the firing device, and is heavier than the displaced water; it therefore rests upon the bottom and requires no anchor. Ground mines are not used where the depth of water exceeds 35 feet.

With respect to the means used to fire them, mines may be classed as mechanical and electrical.

Electrical mines are, in turn, of two general classes, controllable—in which the firing device is under control after the mine has been fixed in position; and noncontrollable—in which no such control is had.

Mechanical and noncontrollable electrical mines are intended to be fired only by the blow of a passing vessel. When once in position they are dangerous alike to friend

and foe, while controllable mines may instantly be made safe for friendly vessels or as quickly made dangerous to vessels of the enemy.

Controllable electrical mines are arranged so as to give a signal to the operator when they are struck. They may be set to fire automatically when struck or tampered with, or may be fired at the will of the operator. In the latter case the firing may be delayed, in which case the operator fires the mine some short interval after the signal indicates that it has been struck; or by observation, in which case he fires it after the position-finding system shows that the vessel has come within the mine's destructive radius.

LOCATION OF MINES.

The considerations involved in the location of mines are of two general classes, tactical and local.

Tactical considerations deal with the position of mines with reference to the other defenses. Local considerations deal with the width and depth of the channel, the swiftness of the current, the variation of the tide, and the relative importance of the harbor.

Where ordinary ship channels are unobstructed it is possible for modern battleships, with their high speed and heavy armor, to run by shore batteries, at least in the night or during a fog; hence the defense of such channels should not be left to guns alone.

On the other hand, where mines are unprotected by the fire of shore batteries it is possible for an enemy to remove or disable them.

Therefore guns and mines, the two elements of the fixed defenses of a harbor, are mutually dependent, and when the location of one has been decided upon that of the other must conform thereto.

Within the zone between 4,000 and 8,000 yards of the main defense the fire of heavy guns is destructive for warships, yet the latter are at such a distance that their rapid-fire guns will be of little effect against the batteries.

Moreover, at 4,000 yards vessels are just beyond the inner limit of mortar fire.

If possible, therefore, hostile vessels should be held in this zone by some obstacle. Such obstacle is afforded by a mine field.

On the other hand, attacks upon a mine field are most liable to be made by small boats at night. If the mine field be at too great a distance from the defenses, these boats will not be revealed by the mine searchlights. Furthermore, for protection against such attacks, the defense relies upon rapid-fire guns of relatively limited range.

Due to the above considerations the outermost mines are usually placed between 3,000 and 4,500 yards from the main defense.

In general, there should be in each main channel at least three lines of mines.

ELEMENTS OF A MINE SYSTEM.

The elements of a mine system are:

1. **The mining casemate,** consisting typically of four rooms: (1) The operating room, containing the power panel and the operating boards; (2) the engine room, containing the engine and the generator; (3) the battery room, containing the storage battery; and (4) the sleeping room for the personnel.

2. **The multiple cables,** 7 and 19 conductor, leading from the casemate out to the distribution boxes, one of which is in the center and rear of each group of mines.

3. **The single-conductor cables,** radiating to the front from the distribution boxes, one leading to each mine.

4. **The mines,** in groups of 19 or less, extending across the waterway to be defended, planted approximately 100 feet apart and anchored so as to have a submergence of about 10 feet at low water. The groups are numbered 1, 2, 3, etc., from left to right of the observer stationed in rear of the line, and the mines in each group are numbered similarly, No. 1 being on the left, No. 10 in the center, and No. 19 on the right.

The groups composing a line of buoyant mines are not usually planted in prolongation of each other, but with a space for the passage of friendly vessels, and also for the movement of the planter when at work upon adjacent groups. Groups of ground mines may be placed in prolongation of each other or between the groups of buoyant mines, as they will always be below the hulls of passing vessels.

5. **The mine planters** and other boats with the necessary equipment for planting and maintaining the planted mines.

6. **The range-finding system,** the same as or similar to that used for the guns, enabling accurate plotting of the positions of the individual mines, and consequently permitting vessel tracking and observation firing.

7. **The searchlights,** for illuminating the mine fields at night.

8. **The rapid-fire guns,** for the protection of the mine fields.

CHAPTER II.

MATÉRIEL OF THE SYSTEM.

The generating set.—This consists of a D. C., shunt-wound generator driven by a kerosene oil engine, or of a direct-connected gasoline set. (For method of operation of a Hornsby-Akroyd oil engine, see Appendix 2.)

The storage battery.—This is a 40-cell chloride accumulator, with a normal charge and discharge rate of 5 amperes. The voltage may be taken at 2 volts per cell; the internal resistance is negligible. Directions for setting up, care, and usage of the storage battery are given in Appendix 3. The 5-ampere battery is the standard equipment at the present time, but the new installations will have batteries with a normal charge and discharge rate of 15 amperes.

The motor-generator, D. C.–A. C.—This is a D. C.–A. C. (60-cycle, single phase) machine, running on D. C. voltage (80–110) and designed to give one-half kilowatt at 80 volts. To insure against breakdown two of these motor generators are supplied to each casemate.

Starting switch.—This is a 4-point lever switch and is used to start the motor-generator and to accelerate it to full speed. To insure against breakdown two of these motor-generators cuit to the fourth-point. Resistances are connected between the points, as shown in figure 1. The contact made at point 1 is not broken as the lever is moved to its successive positions. It is seen that the total resistance is 8 ohms; it is all in the armature circuit when the switch blade is in the first point; 4 ohms when in the second point; 2 ohms when in the third point; none when in the fourth point. The operation of closing the lever short circuits in turn the resistances 4, 2, and 2.

The casemate transformer.—This is a step-up transformer, of the oil-insulated core type, and is rated at 60 cycles, 500 watts, 80 volts primary and 500 volts secondary, when carrying full load.

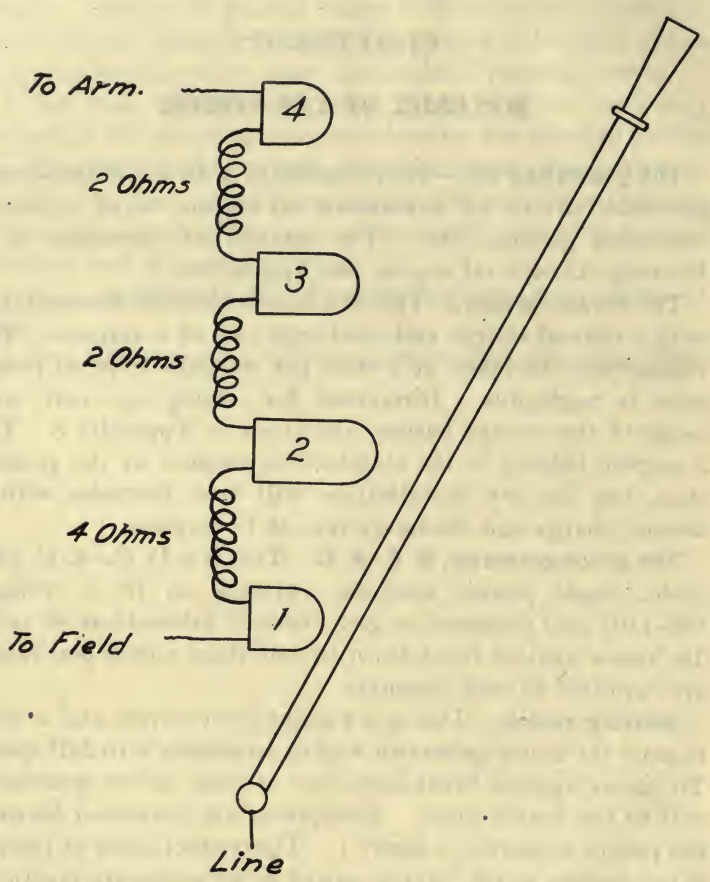


FIG. 1.—Starting switch.

The power panel.—This panel is shown in figure 2, its wiring diagram in figure 18 at the end of the book. It consists of an enameled slate panel upon which the apparatus is mounted. It is 32 inches wide, 69 inches high, and is set up with its face 34 inches from the wall in rear.

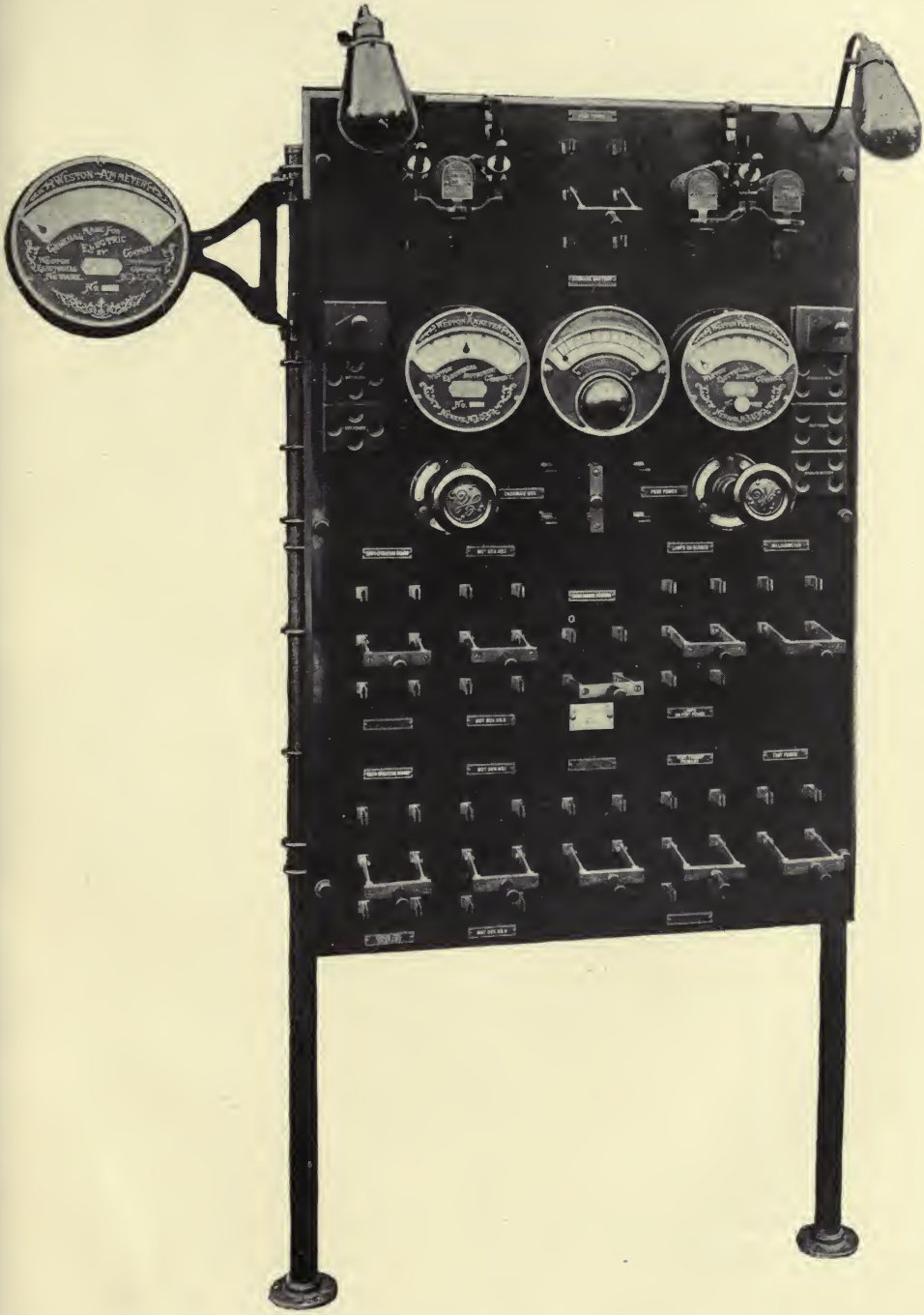


FIG. 2.—POWER PANEL.

Across the top are two lamps, a double circuit breaker, a D. P. D. T. switch, and a single circuit breaker. Below these there are an ammeter, an A. C. voltmeter, and a D. C. voltmeter. Below the ammeter is a battery rheostat and below the D. C. voltmeter a field rheostat. On a bracket at the side there is a mil-ammeter, with a 16 c. p., 110-volt lamp in series with it.

The remaining switches, receptacles, and attachments are sufficiently well indicated in the figures.

Switch No. 1 controls the lamps at the top of the board. When it is up, they are supplied from an external source of power. When it is down, they are supplied from the storage battery.

The D. C. terminals are all carried to one terminal bar, the A. C. terminals to another. All terminals and all switches are labeled.

Provision is made for energizing the D. C. busses:

(*a*) From an external source of power: Close single circuit breaker and close switch No. 2 to the right—facing the board.

(*b*) From the casemate generator: Close single circuit breaker and close switch No. 2 to the left—facing the board.

(*c*) From the storage battery: With switch No. 2 open, close double circuit breaker.

Feeder switches are plainly marked. The D. C. switches supply power as follows:

No. 3. When up, supplies the operating boards (negative pole to boards, positive to earth); when down, it is spare.

No. 4. When up, supplies motor-generator No. 1; when down, motor-generator No. 2.

No. 5. When up, supplies the mine commander's station.

No. 6. When up, supplies casemate lamps; when down, it does the same, but the power is now drawn from an external source and not from the D. C. busses.

No. 7. When up, grounds the positive bus and connects the negative bus through the protective lamp and mil-ammeter to the mil-ammeter lead.

The A. C. switches supply power as follows:

No. 8. When up, supplies the operating boards, one pole to boards, the other to earth through an independent lead;

when down, it does the same, but the side grounded is grounded through a choke coil.

No. 9. When up, energizes the A. C. busses from motor-generator No. 1; when down, the A. C. busses from motor-generator No. 2.

No. 10 is spare.

No. 11. When up, supplies power to the primary of the testing transformer; when down, it is spare.

No. 12. When up, supplies power from the secondary of the testing transformer to the test fuses.

Voltmeter receptacles and plugs, all of which are properly marked, are provided for obtaining the reading of the A. C. and D. C. voltages. The D. C. receptacles are on the right and the A. C. on the left. The first receptacle of each set is spare to hold the plugs when the latter are not in use.

With the D. C. plug:

In the second receptacle, the voltage of the casemate generator is indicated.

In the third receptacle, voltage of external D. C. power.

In the fourth receptacle, voltage of storage battery.

With the A. C. plug:

In the second receptacle, voltage of A. C. power on the busses is indicated.

In the third receptacle, voltage of external A. C. power, if the latter is supplied.

In general, no external A. C. power should be led into the casemate, as the system would be unsafe, owing to the liability of a "cross." The standard system is perfectly safe, as it is impossible for a mine to be fired when the motor generators are idle.

The double circuit breaker is an ordinary single-coil breaker. The single circuit breaker is an overload and reverse-current circuit breaker. The reverse-current coil has two windings, one of which is bridged across the power supply, and the other is in series with it. On charge, the effect of these coils is differential, and on discharge it is cumulative and will trip the circuit breaker when the current from the storage battery exceeds 2 amperes.

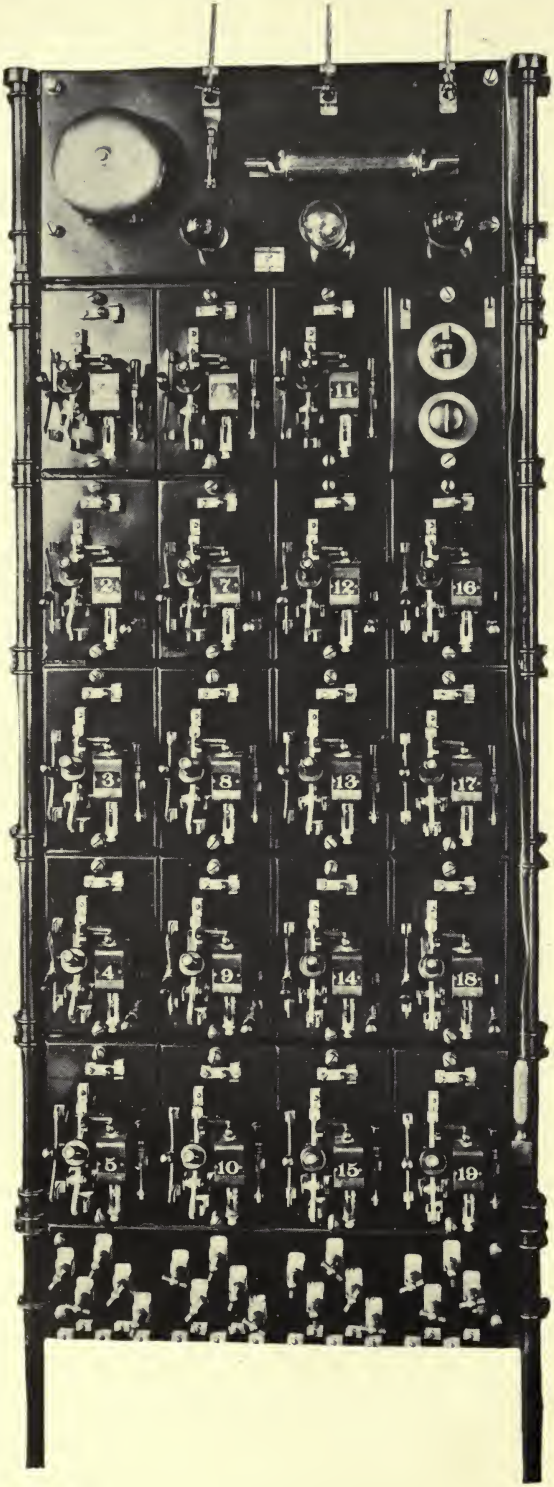


FIG. 3.—OPERATING BOARD.

To charge the storage battery:

(*a*) From an external source of power: Both the single and the double circuit breakers are closed and switch No. 2 is closed to the right (facing the board).

(*b*) From the casemate generator: Both circuit breakers are closed and switch No. 2 is closed to the left (facing the board).

The operating board.—A front view of this is given in figure 3, its wiring diagram in figure 18 at the end of the book. One is required for each group of 19 mines. It consists of an iron frame to which are attached a signal block, a master block, 19 mine blocks (1 for each mine), busses, and a terminal bar with 19 numbered terminals. The frame is 78 inches high by 24 inches wide. It should be set up so that its face is 34 inches from the wall in rear.

The signal block (see fig. 18).—This is an enameled slate block 24 inches wide and 11 inches high, upon which are mounted three binding posts, three lamps (red, white, and green), a bell and bell switch, a 90-ohm noninductive resistance in parallel with the white lamp, and a 125-ohm resistance in series with the bell. The binding posts are marked "Earth" or "G.," "A. C.," and "D. C.," respectively. The bell, the 90-ohm non-inductive resistance, and the 125-ohm resistance are so indicated on the figure. The lamps are marked as follows: Red, "R. L."; white, "W. L."; green, "G. L."

The circuit, under normal conditions, is: From negative D. C. bus on power panel, to switch 3 closed up, to "operating board" terminal, to D. C. lead, to D. C. post on signal block, through green lamp, to D. C. jaw on master block, to D. C. bus on operating board, through power switch P on mine block, through solenoid S, to middle of testing switch T, to upper contact of same, to upper contact of automatic switch A, to middle of same, to mine switch M, through same to terminal bar, through 19-conductor and single-conductor cables, through mine transformer primary, to mine case, to ground, to D. C. "earth" terminal on power panel, to switch 3, and to positive D. C. bus on power panel.

Green lamps of 8, 16, and 32 candlepower are supplied. The 16-candlepower green lamp glows dimly when 19 mines are connected to the operating board and all are free from short circuits, grounds, or abnormal resistances. If it should glow abnormally bright, due to grounds, a 32-candlepower lamp should be substituted. If it should glow very dimly, due to a less number of mines connected, an 8-candlepower lamp should be used.

A short circuit in a mine circuit causes the green lamp to glow more brightly.

Breaks in conductors not causing short circuits will not be revealed ordinarily by this lamp. To detect breaks, tests of individual mines must be made.

The red lamp glows and the bell rings when any automatic switch is down. The circuit under this condition is:

From negative D. C. bus on power panel to switch 3 closed up, to " operating board " terminal, to D. C. lead, to D. C. post on signal block, through green lamp to D. C. jaw, to D. C. operating board bus, through power switch on mine block whose automatic switch is down, through insulated pin of lower arm of automatic switch, to lower point of testing switch T, to operating board lamp bus, through bell, 125-ohm resistance and bell switch, and red lamp in parallel, to " earth " post, to earth lead, to D. C. " earth " terminal on power panel, to switch 3, and to positive D. C. bus on power panel.

The resistance of the bell is such that a resistance of 125 ohms must be placed in series with it to make the joint resistance of the red lamp-bell circuit so large that if one automatic switch is down it will not interfere with the tripping of another.

The white lamp, W. L., is in the firing and A. C. testing circuits. The 90-ohm resistance is in parallel with this lamp, and in addition to protecting it from excessive current, serves to keep the firing circuit complete should the lamp burn out.

The master block (see fig. 18).—This is an enameled slate block 6 inches wide by 9½ inches high, upon which are mounted two jaws for the terminals of a jumper, a testing switch, T. S., and a firing switch, F. S.

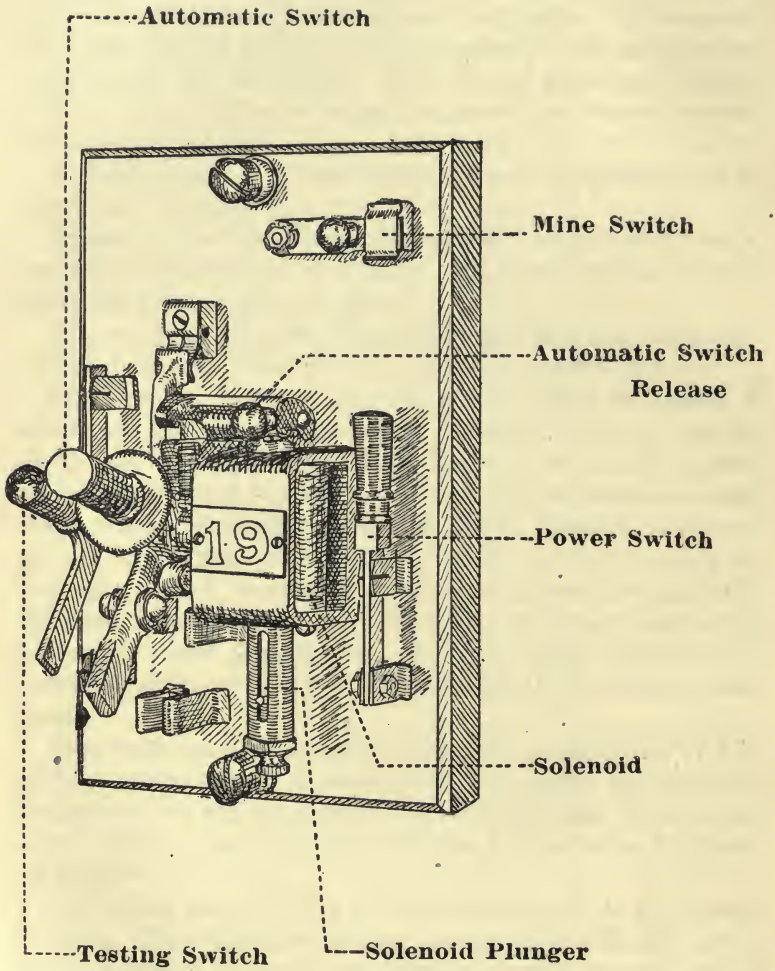


FIG. 4.—MINE BLOCK.

The testing switch, T. S., is used to determine if the A. C. power be on the signal block. If so, when it is closed the white lamp on signal block glows. This switch is marked to indicate its "off" and "on" positions. When "on" the circuit is as given in "test of the delivery of the A. C. power to the operating board," Chapter VI.

The firing switch, F. S., is used to throw the A. C. power on the operating board A. C. busses. This is marked to show its "on" and "off" positions. No mine can be fired unless this switch is in its "on" position. When "on" the firing circuit is as follows:

From A. C. bus on power panel to switch 8 closed up, to "operating board" terminal, to A. C. lead, to A. C. post on signal block, to white lamp and resistance in parallel, to A. C. jaw, through firing switch, F. S., to A. C. bus on operating board, to lower point of automatic switch when it is closed down, to middle point of automatic switch, through mine switch to terminal bar, through 19-conductor and single-conductor cables, through mine transformer primary, to mine case, to ground, to A. C. "earth" terminal on power panel, to switch 8, and to other A. C. bus on power panel. The white lamp glows after the mine has been fired.

The mine block (see figs. 4 and 18).—This consists of an enameled slate block, 6 inches wide and 9½ inches high, on which are mounted four switches.

1. The upper switch is the "mine switch." When it is open the corresponding mine is cut out and can not be fired. It is placed horizontally on the blocks of the old model and vertically on those of the new model.

2. The right-hand switch, a S. P. S. T. knife switch, is the "power switch." When it is closed the D. C. power is on the block and the automatic switch will function when the corresponding mine is struck. When it is open the mine can be fired by raising the automatic switch release, thus tripping the automatic switch.

3. The central switch is the "automatic switch," a single-pole double-throw switch, operated by the plunger of a solenoid. Through its lower arm there passes an insulated pin

which, when the switch is down, makes connection between two contacts to the right and left of this arm.

If for any cause the current through the solenoid rises above that for which it is set (normally 0.075 ampere), its plunger is drawn up and the switch is tripped. Such rise in current is produced when a mine is struck, the resistance through the circuit-closer circuit being far less than that through the primary coil of the transformer. Such would also be the case when a mine cable is grounded.

When the automatic switch is tripped, the D. C. circuit to the mine is broken at its upper contact (see fig. 18) and D. C. circuit through red lamp and bell is made through the insulated through pin in the lower arm, thus giving warning. If at the same time A. C. power be on the busses and the firing switch on the master block be closed, A. C. will be thrown on the mine through the lower contact of the automatic switch, and the mine will be fired.

Just above the plunger of the solenoid there is a red knob attached to the tripping bar of the automatic switch release. This enables the automatic switch to be released by hand in observation firing and in testing.

4. The left-hand switch, a S. P. D. T. switch, is the "testing switch." It is used to test the automatic switch, which should open when the testing switch is thrown down. The bell switch should be opened before throwing down testing switch. When the testing switch is in this position, the circuit being broken at its upper contact, the mine is cut out, and in place of the mine there is thrown in the red lamp of the signal block. The resistance of this red lamp is greater than that of the mine circuit when the mine is struck, so that if the automatic switch works for the current through the red lamp it will certainly work for that through the circuit closer when the mine is struck.

The circuit when the testing switch, T, is down and *before* the automatic switch drops is: From negative D. C. bus on power panel, to switch 3 closed up, to "operating board" terminal, to D. C. lead, to D. C. post on signal block, through green lamp, to D. C. jaw, to D. C. bus on operating board, through power switch, through solenoid to middle of testing

switch T, to lower point of same, to operating board lamp bus L, through red lamp to "earth" post, to earth lead, to D. C. "earth" terminal on power panel, to switch 3, and to positive D. C. bus on power panel. The circuit, when testing switch, T, is down, and *after* the automatic switch has dropped, is the same as the above up to the power switch, then from the power switch through the insulated pin in the lower part of the automatic switch, to the lower jaw of the testing switch, and then the same as the circuit above.

A diagram similar to the wiring diagram, figure 18, at the end of the book should be made of the power panel and of one of the operating boards of each casemate and posted in a conspicuous place in the casemate. Any changes made in the wiring of either of these boards should be made immediately on this diagram.

Submarine mine cable, 19-conductor.—This is an armored cable about 1 inch in diameter and contains 19 insulated single conductors of No. 16 American wire gauge wire (51 mils in dia.). The conductors are arranged in two concentric layers around a single central conductor, the inner layer containing 6, the outer 12. One conductor in each layer is distinguished from the rest by some characteristic mark, as a spiral white thread, a wrapping of tape, or other easily detected mark. The marked conductor in the outer layer is No. 1, that in the inner layer No. 13, and the central conductor is No. 19. The other conductors are numbered at the shore end of the cable in a clockwise direction; at the distant end in a contraclockwise direction.

Submarine mine cable, 7-conductor.—In many cases the 7-conductor cable now on hand can be used to advantage for mine work, particularly in planting groups which do not require great lengths of multiple cable. In all such cases the old grand junction boxes are to be used as distribution boxes, thus providing for separate groups of 7 mines.

Submarine mine cable, single conductor.—This is an armored cable, about three-fourths inch in diameter, and contains an insulated conductor made of 7 strands of soft annealed No. 22 American wire gauge copper wire (25.35 mils in dia.).

The buoyant-mine case.—The service 32-inch pattern is made of 10-pound, ¼-inch, open-hearth steel, of great toughness and elasticity, and is thoroughly galvanized. The shell consists of two hemispheres, ribbed and welded together at the equator, thus avoiding all rivets. Every case before it is accepted is tested with an internal hydraulic pressure of 100 pounds per square inch.

The top hemisphere is provided with an external maneuvering ring; the bottom hemisphere has a hole 5½ inches in diameter at the pole. The edge of the hole is reenforced by a welded ring 1½ inches thick; and near it are four bosses, also welded, carrying screw bolts which project 2½ inches outside to secure the cap.

The cap consists of a hemisphere of 15-pound, ⅜-inch wrought iron, flanged and dished at the base to fit the case, to which it is attached by the four bolts already mentioned. They pass through slots in the flange, which is then held in place by shoes and nuts which are keyed on. The water has free access to the chamber inside the cap. The uses of the cap are: To clamp the Turk's-head of the mine cable, to cover and protect the portion of the core exposed outside the case, and to serve as an attachment for the wire mooring rope.

A hole 1½ inches in diameter at the pole of the cap is connected by means of a slot with a 3-inch hole punched through the cap between two of the bails. This arrangement permits the entrance or removal of the Turk's-head without removing the cap from the mine case. The mooring attachment consists of a ring of 1½-inch wrought iron, having a hole 2½ inches in diameter, attached to the cap by three bails of 1-inch wrought iron permanently double riveted to the sides. The cap is thoroughly galvanized.

The large hole in the mine case covered by the cap is closed by a plug. The joint is made water tight by a lead washer jammed between the plug proper and the case and by a coating of red lead or similar waterproofing material upon the screw threads. In the strong currents and deep water of some harbors more buoyancy than is possessed by the 32-inch case is required. This is obtained by inserting between the

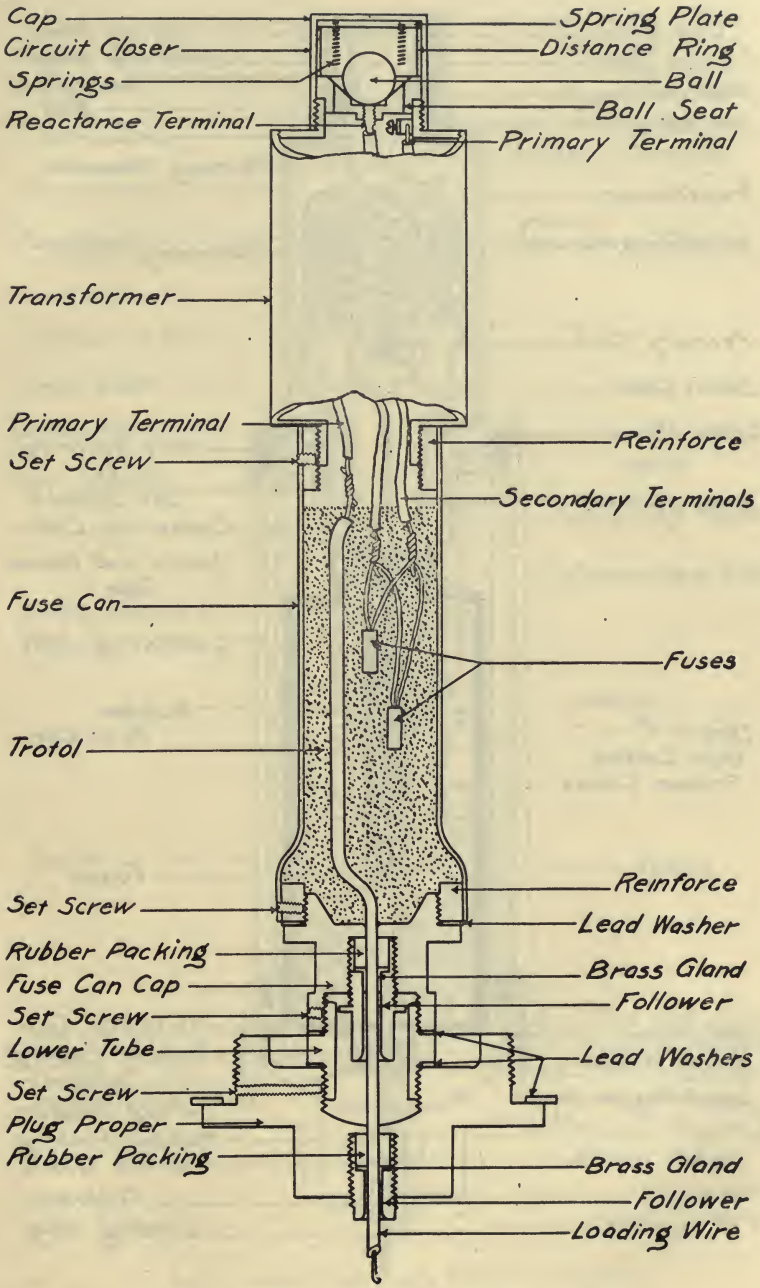


FIG. 5.—COMPOUND PLUG, OLD MODEL FUSE CAN.

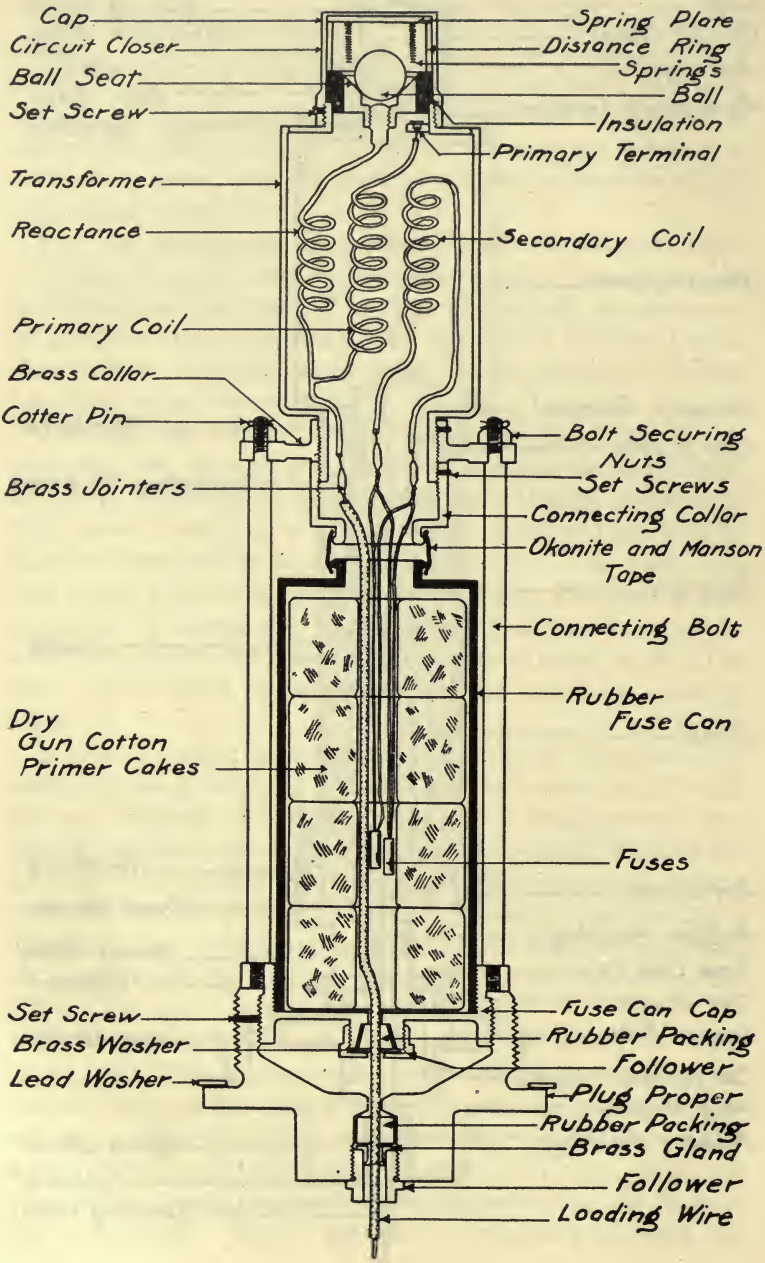


FIG. 6.—COMPOUND PLUG, RUBBER FUSE CAN.

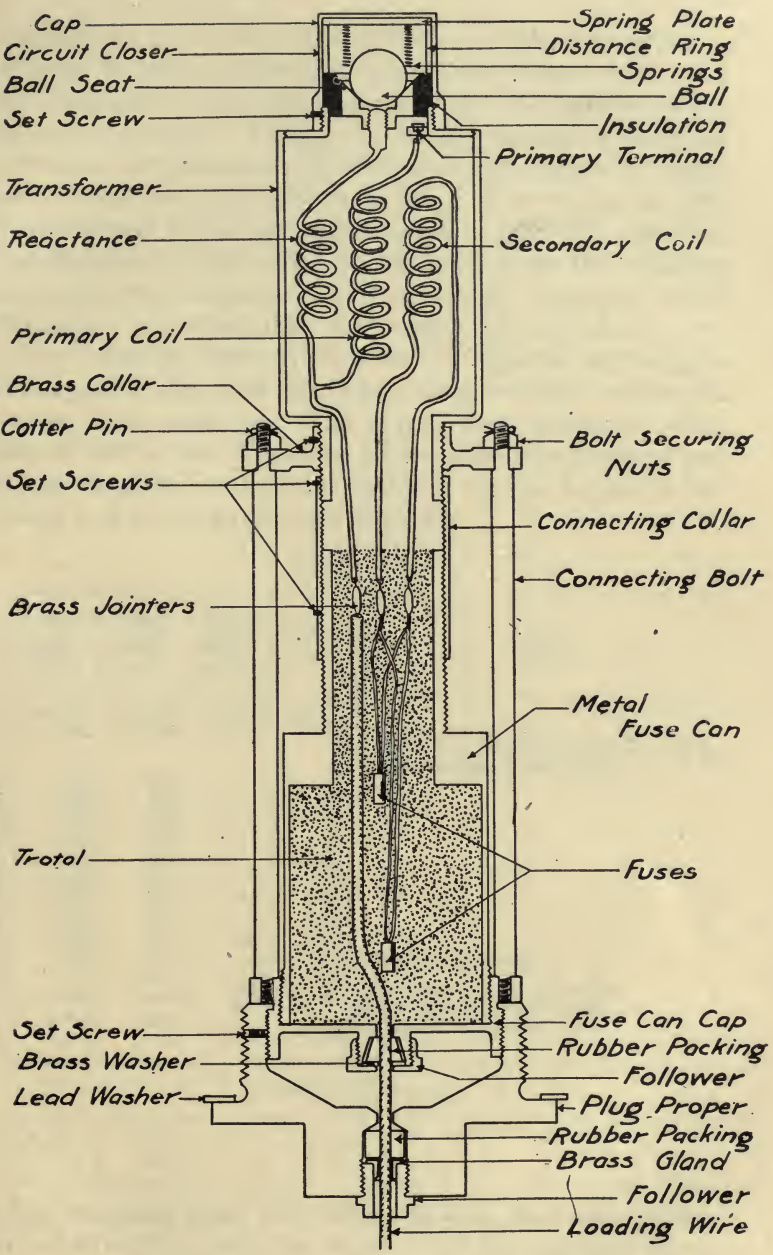


FIG. 7.—COMPOUND PLUG, TROTOL FUSE CAN.

hemispheres a cylinder of 20-pound wrought iron which is stiffened by extra welded ribs for the larger sizes. Such cases are designated by the diameter in inches of a sphere having the same buoyancy. Thus, a No. 40 case is made by inserting a cylinder 32 inches in diameter and 20.4 inches in length between the two hemispheres of a No. 32 case; this is sufficient to make the displacement equal to that of a spherical case 40 inches in diameter. In the latest types the cylinders are made of corrugated mild steel of less thickness, which diminishes very materially the weights of the cases.

The following table exhibits the dimensions and weights of buoyant mines, with trotol fuse cans, complete except the charges and moorings. The actual free buoyancy when planted will be the difference between the displacement and weight as given in the table, reduced by the weight of the charge and of the moorings and cables:

PLAIN CASES.

No.	Displacement.	Computed weight, empty.	Measured weight, empty.	Length of cylinder.	Remarks.
	Pounds.	*Pounds.*	*Pounds.*	*Feet.*	
32	635	308	311	0.00	All are about 33½ inches in outside diameter; the extreme length in each case is 4.3 feet plus the length of the cylinder.
33	695	364	.....	.17	
34	762	395	.....	.35	
35	829	427	.....	.54	
36	904	462	.....	.75	
37	982	498	.....	.96	
38	1,064	538	.....	1.20	
39	1,149	578	.....	1.43	
40	1,242	621	625	1.70	
41	1,341	665	.....	1.96	
42	1,436	712	.....	2.24	
43	1,540	788	759	2.53	
44	1,652	842	.....	2.77	One extra welded rib.
45	1,767	876	.....	3.17	Do.
46	1,887	952	899 936	3.50	Lot of 1879; one extra welded rib. Lot of 1884; one extra welded rib.
47	2,013	1,011	.....	3.85	One extra welded rib.
48	2,144	1,073	1,037	4.20	Do.

CORRUGATED CASES.

47	1,536	572	.....	2.24	
50	2,323.2	777	.....	4.22	

The compound plug, with old model brass fuse can.—A section of this plug, with the names of all the parts, is shown

in figure 5. The brass fuse can is not used when guncotton is used as a priming charge.

The compound plug, with rubber fuse can.—A section of this plug, with the names of all the parts, is shown in figure 6.

The compound plug, with trotol fuse can.—A section of this plug, with the names of all the parts, is shown in figure 7.

In each plug the main parts are screwed together and held in place by set screws. The connection of the compound plug with the mine case makes an earth plate, of which the electrical resistance in salt water is about 1 ohm.

The mine transformer (see fig. 8).—This consists of a cylindrical brass case, which contains the primary and secondary coils of the transformer and the reactance coil. The transformer is screwed into the brass collar or the reenforce and in turn has the circuit closer screwed upon its top. The fuses are attached to the secondary and are fired when proper voltage is applied to the primary. The primary leads are black; those of the secondary are red. The terminal, P′, of the primary coil is left free for the purpose of testing, but when preparing the transformer for use it is attached securely to the binding post, T. The upper terminal, R′, of the reactance is prepared for attachment to the ball seat of the circuit closer.

The normal circuit is from P, through the primary coil (the resistance of which is about 2,400 ohms), to the transformer case, and thence to earth. However, when the mine is struck, so as to close the circuit closer, a parallel circuit is closed through the reactance (the resistance of which is about 130 ohms), thence to the ball seat of the circuit closer, through the ball and springs to the transformer case, and thence to earth. In this latter case, therefore, the resistance is lessened by about 2,300 ohms.

The reactance coil will permit only a small amount of alternating current to pass through it when the ball is displaced, hence mines may be fired whether the ball is displaced or not.

Two fuses are connected in multiple across the ends of the secondary terminals. These terminals are 10 inches in

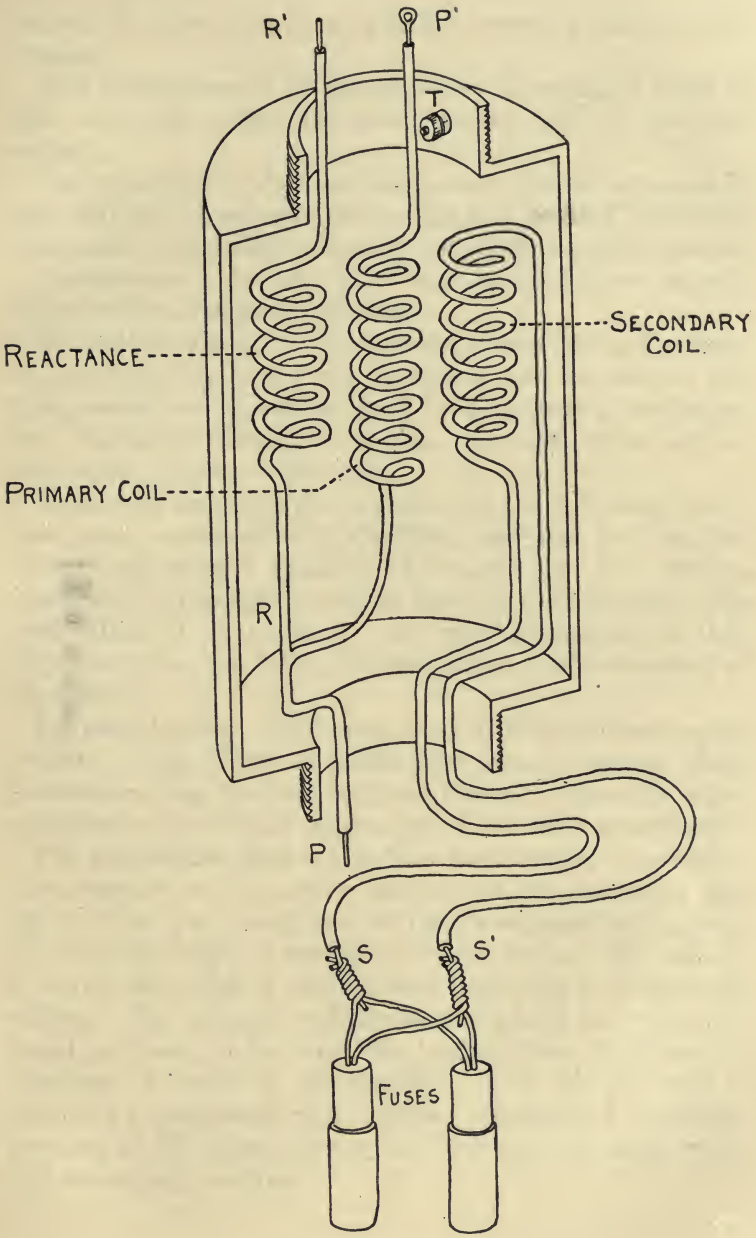


FIG. 8.—MINE TRANSFORMER.

length, to allow ample margin for inserting fuses in the primer.

The transformer is of the step-down type and is rated at 22.5 watts, 60 cycles, 500 volts primary, and 14 volts secondary.

The mine circuit when normal is such that 80 volts should give only 30 mil-amperes, but a mine may be fired even when the circuit is so defective that 80 volts give 120 mil-amperes.

Furthermore, 150 volts D. C. may be applied to the primary without danger of explosion.

An explosion can not be produced unless the A. C. busses on the operating board are energized, and as long as the firing switch on the master block is open, there is no danger from accidental closing of switches in making mine tests or from short circuits in the mine.

NOTE.—In designing this transformer the following variations were considered: (*a*) Omitting reactance and tapping to ball seat beyond primary of transformer; (*b*) using a condenser; (*c*) using two sets of fuses, so as to be able to fire with either D. C. or A. C. All were eliminated, as they impaired either the safety, the simplicity, or the efficiency of the system.

The circuit closer.—This, when used with the buoyant mine, consists of the following parts: The cap, the spring plate, the distance ring, the steel ball, and the ball seat, which, when assembled, are mounted on the top of the mine transformer.

The ground-mine case.—The form and details of construction adopted for the service pattern are the following (see fig. 9): The case is cast iron, in form a segment of a sphere, of which the height is two-thirds of the radius. The bottom is nearly flat, with a central sand-hole plug to empty the casting. Six internal radial ribs are added to give additional supports to the top; the loading hole, $5\frac{1}{2}$ inches in diameter (3 inches in old pattern), is at the pole and is closed by a compound plug. Before acceptance a hydraulic pressure of 100 pounds per square inch must be borne without developing leakage.

Only one size of ground mine has been introduced into our service. This pattern is designed to contain from 200 to 300 pounds of explosive and to rest on the bottom in water not exceeding 35 feet in depth at high tide. The dimensions are as follows: Radius of the sphere, $21\frac{2}{10}$ inches; diameter of the base, 40 inches; extreme height, 25 inches; thickness of iron, seven-tenths of an inch; weight, empty in the air, 1,355 pounds; when submerged it loses 515 pounds. The capacity of this case is about 5 cubic feet.

A mine cap is provided to clamp the Turk's-head of the mine cable, to cover and protect the portion of the core

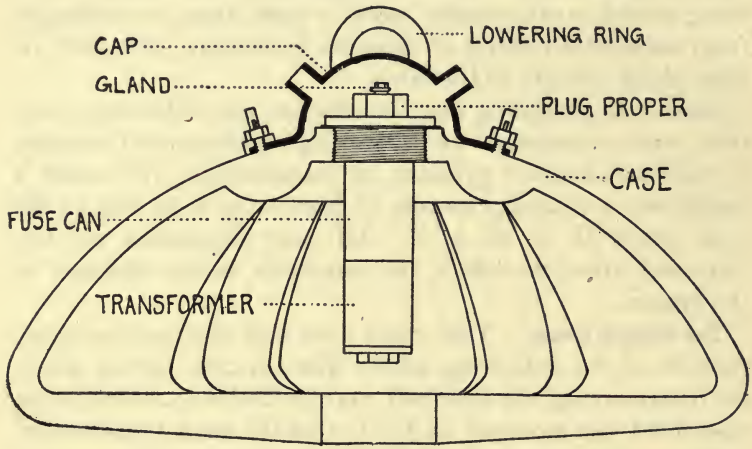


FIG. 9.—Ground-mine case.

exposed outside the case, and to serve as an attachment for the mooring and the raising ropes. This cap is held to the mine case by six bolts, and is fitted with two rings, one for attachment of the mooring rope of the circuit-closer buoy and the other for attachment of the raising rope.

The compound plug, ground mine.—This is similar to the compound plug for buoyant mines. The circuit closer is placed in a buoy above the mine.

The mushroom anchor.—The 1,000-pound anchor is in shape a right cylinder about 10 inches in height and 26 inches in diameter, slightly dished on the bottom to increase the hold-

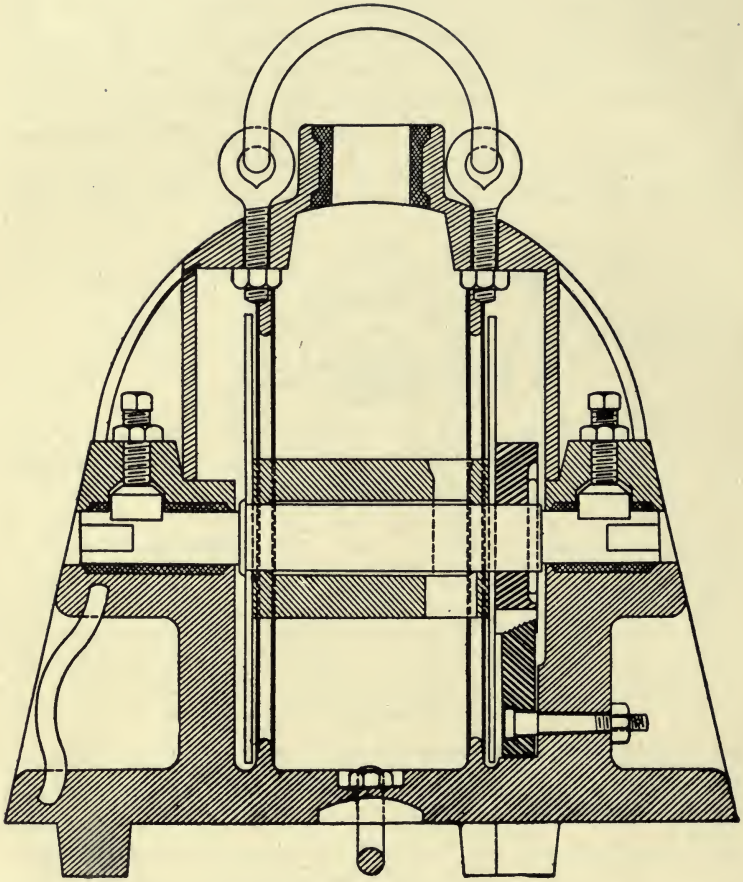


FIG. 10a.—AUTOMATIC ANCHOR.

ing power in mud. For a rock bottom six projecting toes increase the holding power; corresponding depressions on the top permit piling when in store. The heavy anchors, 2,000 and 3,000 pounds, are of the same form. The cylindrical form is adopted to facilitate handling, since in that shape the anchor may be rolled readily on its edge.

The absolute stress of the mine and its moorings upon a mushroom anchor of this kind is easily computed, being the square root of the sum of the squares of the buoyant effort and of the horizontal pressure exerted by the current. The latter, in pounds per square foot of exposed cross section, may be estimated at one-half the square of the velocity of the current in feet per second. A coefficient of safety should cover the jerking effect of the waves and the shocks of friendly vessels. It will, of course, vary with the locality and with the absolute weight of the anchor, but in general a value from 3 to 5 is considered sufficient.

The holding power of such an anchor varies greatly with the nature of the bottom. If this be hard, the dead weight alone must be depended upon; if soft, at least double power may be anticipated. In swift water the buoyant mine can be better held in position by two anchors chained together.

The shackles.—The wire mooring rope is attached to the anchor and to the case by shackles, of which there are two sizes. The anchor shackle consists of a wrought-iron strap with two eyes bent into the usual curved form and offering a thickness of $1\frac{1}{2}$ inches at the bottom, where the wear and sand cutting is greatest, and of a $1\frac{1}{2}$-inch wrought-iron bolt fitted flush with the outside of the straps. The bolt is held in position by a split key, which, after insertion through a small hole in the bolt and one of the eyes (in the old model), is opened so that it can not work loose.

The mine shackle is lighter, being 1 inch thick at the bottom, with a 1-inch bolt; otherwise it is identical in pattern with the anchor shackle.

Sister hooks.—They are used to connect the bail of the mushroom anchor to the anchor shackle. They are of drop-forged steel of high tensile strength and weigh about 7 pounds per pair.

The automatic anchor, Artillery type, 1910 (see figs. 10 *a* and *b*).—This is a device intended for use with buoyant mines, and by means of which such mines may be anchored in any depth of water, with any desired depth of submergence given automatically.

The anchor is bell-shaped, 28 inches in diameter at the bottom, 28½ inches high over all, and composed of the following parts: Body, cover, reel, journal-box caps, ratchet, pawl, pawl spring, distance rope, distance weight, brakes, bails, necessary bolts, wrenches, and crank handles.

The pawl is drawn away from the ratchet by a weight suspended a certain distance below the anchor. This is called the distance weight, and the submergence is regulated by the distance this weight is from the anchor. In falling through the water the mooring rope will unreel and the mine will remain on the surface, but when the distance weight reaches the bottom the pawl spring forces the pawl into the teeth of the ratchet, and as the latter is attached to the reel shaft, it prevents the reel from turning and hence unreeling.

These anchors weigh approximately 1,500 pounds, including the 200-pound distance weight.

In order to control the speed of revolution of the reel, the friction brakes must be adjusted properly. To do this, a pull is put on the mooring rope with a spring balance rigged to show the amount of pull; the pull for a particular size of case is determined by experiment. For a No. 40 mine case the adjusting screws of the brake shoes are regulated so that the reel will revolve slowly when a pull of 300 pounds is registered.

The pawl spring is 9½ inches long and of such strength that a pull of 36 pounds will extend the spring 1½ inches. The pawl-spring bolt is of such length that the pawl spring will be just at the point of tension when the top of the pawl-spring bolt is flush with the top of the pawl-spring-bolt nut and the pawl fully seated in the ratchet.

When the tidal currents are such as to require a heavier anchor to hold the mine than the 1,500-pound automatic anchor, the following combination anchor will be used: Attach a mushroom anchor by means of a mooring rope (about

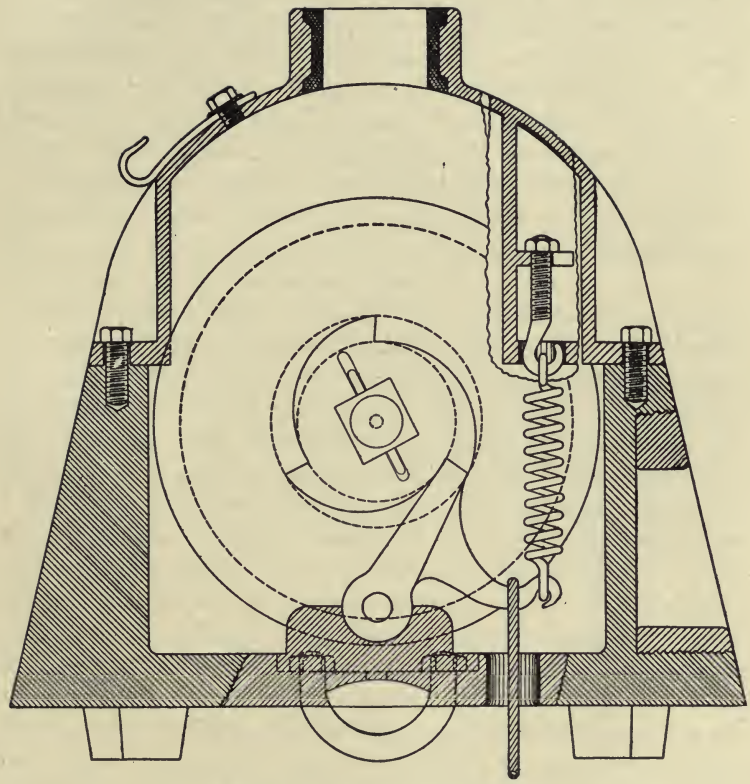


FIG. 10b.—AUTOMATIC ANCHOR.

8 feet long) and clips to the bail in the bottom of the automatic anchor. If necessary, two mushroom anchors may be fastened together by bolts and these attached to the automatic anchor as stated above.

A 3,000-pound automatic anchor, similar to the 1,500-pound automatic anchor, is supplied for some localities.

The mooring sockets.—To connect the wire mooring rope to the shackles at the mine and the anchor, a closed socket is attached at each end. The eye of the socket has a clear opening, $1\frac{3}{10}$ inches, designed to receive the bolt of the shackle. The end of the rope is passed into the socket, spread out, and secured by pouring in a melted socket alloy.

A substitute method for connecting the wire mooring rope to the shackles is to bend the ends of the mooring rope by means of a small vise around a galvanized-iron thimble and fasten the end by two bolted clips.

Wire mooring rope.—This is the highest grade of $\frac{3}{4}$-inch galvanized-steel wire rope, consisting of 6 compound strands, each made of 19 wires, the whole laid around a steel center. Its breaking strength when new is about 18 tons. Its weight per running foot, submerged, is about eight-tenths of a pound. It is used for mooring mines to mushroom anchors.

Marline-covered wire mooring rope.—For mooring mines to the automatic anchors and for raising rope marline-covered wire rope is used. This rope consists of five outer strands wound around a central hemp core. Each of the outer strands consists of a small twisted wire rope wound around with four strands of marline. One end of the rope is prepared for attachment to the mine by passing it over a thimble and fastening it to the standing part by means of two clips. A shackle joins the thimble and the bail of the mine. The other end of the rope is made secure to the reel of the anchor. The breaking strength of $\frac{1}{2}$-inch marline-covered rope is 17,000 pounds, that of $\frac{5}{8}$-inch marline-covered rope is 27,000 pounds. The weight per running foot of the $\frac{1}{2}$-inch rope is 0.5 pound, that of the $\frac{5}{8}$-inch rope is 0.8 pound. The weight of this rope submerged is about 60 per cent of its weight in air.

About 155 feet of the ½-inch and 85 feet of the ⅝-inch marline-covered rope can conveniently be wound on the 6-inch reel of the 1,500-pound automatic anchor.

Marline-covered wire distance weight rope.—For attaching distance weights to the automatic anchor ¼-inch marline-covered wire rope is used. This rope is identical in pattern with the marline-covered wire mooring rope.

The distribution box, 19-conductor.—This is a circular, cast-iron, disk-shaped box which receives the end of the multiple cable, in which taped joints are made between the separate conductors of this cable and the single-conductor mine cables, and from which these mine cables radiate. It is about 27 inches in diameter and weighs about 300 pounds. It consists of two parts, a bowl-shaped bottom 6 inches deep inside and a slightly curved lid. The latter has an iron ring in its center by which the box is raised and lowered.

Eight pins, fastened to the bottom, fit in corresponding holes in the edges of the lid and are slotted for keys by which the two parts are fastened together.

The vertical edge of the bottom is cut with 20 slots, each about 2½ inches deep. One of these is larger than the others and receives the multiple cable; the others are for the single conductor cables. When in use these slots are numbered clockwise from the multiple-conductor slot, looking down into the box. The lid has corresponding projections or lugs which enter these slots, and which, in position, fit snugly against the cable ends. The cables are held from being pulled out by Turk's-heads worked upon them.

To prevent the cable ends from accidentally slipping out of the slots while joints are being made between them before the lid is put on, the multiple cable is secured by a bolted collar on the inside of the box, the single-conductor cables by clipping their Turk's-heads under claw-like radial projections cast upon the inside rim between the slots.

The distribution box, 7-conductor.—This box is used with multiple cable, 7-conductor. It consists of two circular plates of cast iron 21 inches in diameter and three-fourths of an inch thick united by four 1-inch bolts, which are placed in rounded projections forming the angles of a square. The

cables are separately clamped, the top plate overlapping the clamp straps. The multiple cable enters on one side; three single-conductor cables enter on the opposite side, and two on each of the intermediate sides. The top plate is provided with a lowering ring.

The junction boxes.—These boxes, in different sizes, are used in splicing multiple and single-conductor cables; they consist of two rectangular plates of iron or steel united by four ½-inch bolts at the corners. The plates are hollowed in the middle to form a chamber to receive the Turk's-heads and the joints connecting the conductors. The ends of the plates are curved to admit the cable ends. The Turk's-heads are clamped to the lower plate by straps and screw bolts, the cavity of the upper plate covering them when bolted in position. Each cable end is thus made fast before the box is closed.

The distribution-box buoy.—This buoy is used to mark the position of the distribution box during the planting of mines and subsequently, in practice and in service, until such time as the mine commander desires to remove it. It may be either a can or a keg buoy—a beer keg of one-half barrel capacity is well suited for this purpose.

The mine buoy.—This buoy is used to mark the position of the mine when planted. It may be a small can buoy, preferably cork filled, or a piece of wood with a hole bored through it. The size of the buoy is determined by the swiftness of the current. It is attached to the maneuvering ring of the buoyant mine by 60 feet of ½-inch rope.

The measuring reel and frame.—The frame consists of two longitudinal pieces, 3 by 4 by 66 inches, placed 17 inches apart, center to center. At 11½ inches from each end two cross pieces, 3 by 4 by 20 inches in length, are fastened to the longitudinal pieces with through bolts. At the center point of these cross pieces are placed standards, 3 by 4 by 16¾ inches, which have journals for the axle of the reel, countersunk in their upper ends. Two iron braces, one on each side, hold each standard firmly in a vertical position. An iron clamp is also attached to the upper ends of the standards, by means of which the axle is prevented from jumping out of

the journals. Distance from center to center of standards is 43 inches.

The iron axle of the reel is 1½-inch round iron, 54 inches in length. At each end of the axle a screw thread is cut for the nut which holds the crank in place. Inside the screw thread the axle is squared to receive the socket of the crank. Two collars prevent the wooden reel from binding on either standard. The cranks are of the usual design. The drum of the reel is 8½ inches in diameter; heads are 2½ inches thick, made in two layers, cross-grained, and are 24 inches in diameter; length of drum over all is 36 inches. Iron plates are fastened in the center of each head, through which the axle passes. The reel is prevented from turning on the axle by keys.

Three ¾-inch rods pass through the iron plates and drum and bind these parts firmly together.

At 6 inches from the ends of the longitudinal pieces a hole is bored to receive a lag screw, ½ inch by 6 inches, by means of which the whole apparatus can be firmly fastened to the deck.

The brake is a piece of 3 by 3 by 36 inch hardwood, used as a lever to bring pressure on the drumhead. There is one for each side, and, when not in use, each rests on one of the longitudinals, being held in place at one end by two staples and at the other end by a bolt and pin.

Near the drum on one head is a hole through which the inner end of the measuring line can be passed and stapled to the outside of the head.

The cable-reel frame.—The frame is made in two parts which, when in use, are held in proper relative positions by means of two iron ties provided with turnbuckles at their centers. The ends of these ties are bent over at right angles and fit in sockets in the two end parts.

Each end part consists of a standard having an iron head through which works a screw turned by a small lever, the upper end carrying a journal in which the end of the reel axle rests. The lower end of the standard rests on a horizontal piece and has a diagonal brace on each side, the outer ends of these braces being dovetailed into the longitudinal piece

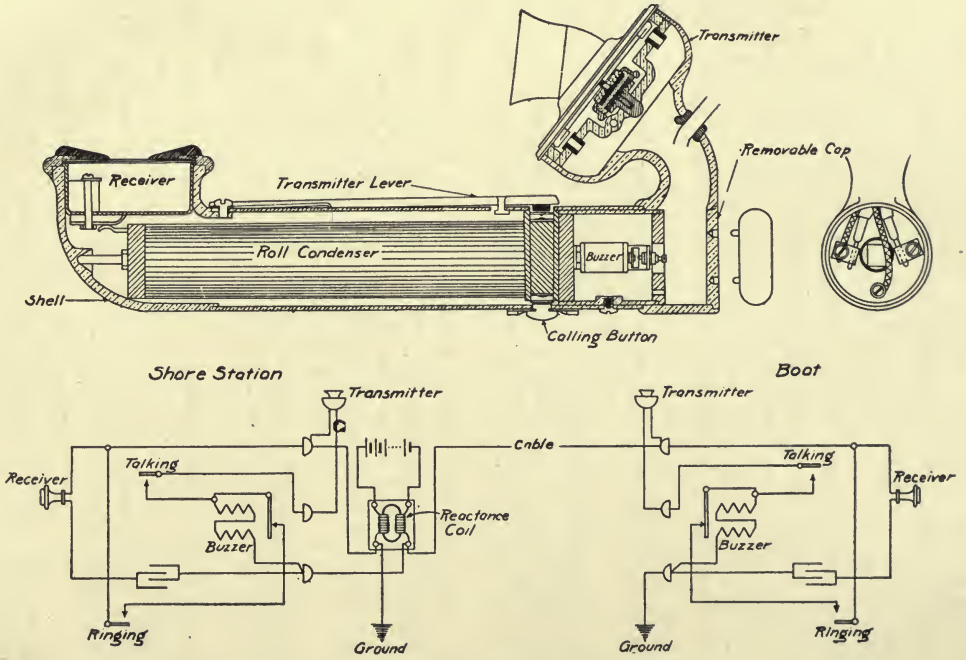


FIG. 11.—BOAT TELmPHONE, MODEL 1906.

and the inner ends into the standard near the top. Dovetailed into the longitudinal piece at its middle point is a piece extending out at right angles, bottom flush with bottom of the longitudinal. A diagonal brace similarly fastened prevents any outward movement of the standard. The whole is held firmly together by bolts and lag screws.

Lag screws are also provided, by means of which the ends of the frames can be fastened to the deck of the vessel if desired.

The reel axle is $2\frac{1}{2}$ by $2\frac{1}{2}$ inch squared iron, rounded at the ends for 6 inches to fit the journals of the frame. A disk secured by a set-screw at one end of the axle and the friction brake wheel at the other end hold the axle in position with respect to the reel.

The brake wheel is 18 inches in diameter. The friction band is $1\frac{1}{2}$ inches by $\frac{1}{8}$ inch, and is fastened at one end to one of the standards of the frame. The other end is attached to a lever whose fulcrum is also attached to the same standard.

Boat telephones.—The different models in use are as follows:

(*a*) *Model 1904.*—The system consists of two telephone hand sets, a buzzer, and a battery of dry cells of about 8 volts, all connected in series by means of cable and earth connections.

In operating the telephones a call is made by pressing the button, and when talking the lever is held down.

(*b*) *Model 1906.*—The system consists of two telephone hand sets, a reactance coil, and a source of energy that will furnish about 15 volts, dry cells preferred, connected as shown in figure 11. The terminals do not have to be poled, as the receiver is not in the primary circuit and can not be demagnetized.

To regulate the buzzer, remove the cap in the base and with a small screw driver loosen the lock nut on the center screw (a small portion of a turn is all that is necessary). With a smaller screw driver the screw may be adjusted to increase or decrease the rate of vibration, increasing or decreasing the sound. Then tighten the lock nut. In case the contact is dirty the entire buzzer and condenser may be

removed by disconnecting the cord and removing the screw on the back of the telephone just below the call button. As the contacts are aluminum, this will seldom have to be done.

(*c*) *Model 1909.*—The system consists of two telephone hand sets, an apparatus box, and a battery of from 7 to 10 volts, all connected as shown in figure 12. The talking and ringing circuits are normally open at the talking and ringing buttons, respectively.

Apparatus box.—Seven dry cells in series should be connected to the posts of the apparatus box marked "+" and "—," and the post marked "G" connected to a ground plate.

Shore hand set.—The blue cord of the shore hand set should be connected to the ground plate. Either of the red cords of the shore hand set should be connected to the post in the apparatus box marked "L" and the other to the conductor in the cable that is to be used for telephoning purposes.

Boat hand set.—The blue cord of the boat hand set should be connected to the ground plate and one of the red cords to the conductor in the cable to which the hand set on the shore is connected. The other red cord is free.

Signaling.—From figure 12 it will be seen that in either hand set, when neither the ringing nor the talking switch is closed, a condenser within the hand set is in series with the transmitter and the receiver, so that the practical effect is to permit an alternating or variable current to pass through the transmitter and the receiver, but to prevent a direct or continuous current from so doing.

By pressing the ringing key of either hand set the circuit in that hand set is closed through the 1,000 ohms resistance and the receiver to ground. Thus, when the ringing key of the boat hand set is pressed, this allows the direct current from the battery to pass (see fig. 12) through f, e, d, c, "B," b, a, line, the ringing key, 1,000-ohm resistance, and receiver of the boat hand set, to ground, and back through o and p to battery. Similarly, a circuit through the battery, f, "A," and a, is made, thus placing relays "A" and "B" in parallel. The relay "B" operates, but relay "A," being less sensitive than "B," does not operate. Relay "B" closes the circuit at l, and thus completes the circuit from battery through f, e, d,

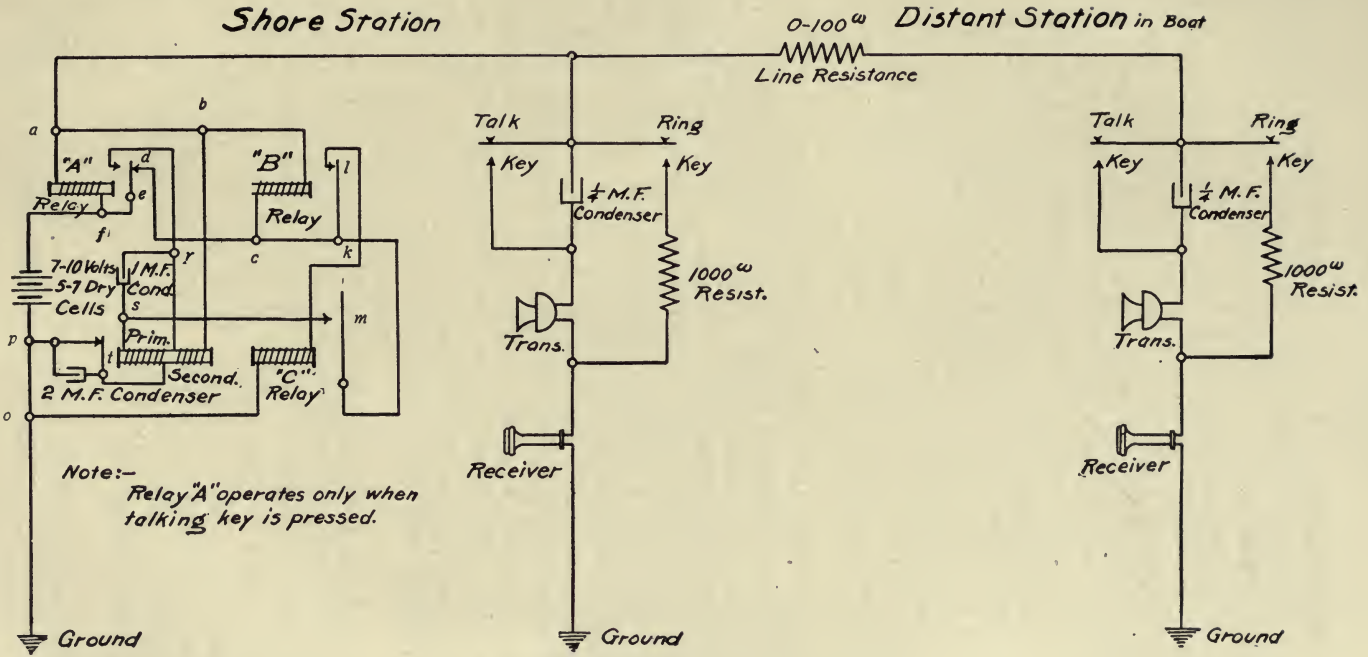


FIG. 12.—BOAT TELEPHONE, MODEL 1909.

c, k, l, "C," o, p, back to battery. This causes relay "C" to operate and to complete a local circuit from battery through f, e, d, k, m, s, primary, t, vibrator, p, back to battery, causing the vibrator to vibrate and inducing in the secondary winding of the induction coil an alternating current, which passes through the 1 M. F. and 2 M. F. condensers, through the hand sets in parallel, and by alternately increasing and decreasing the attraction of the receiver magnets for their diaphragms produces a loud humming sound in each receiver.

Similarly the shore station may call the boat station.

Talking.—When the ringing key is released and the talking key is depressed the 1,000-ohm resistance is cut out and the condenser in the hand set is short circuited. The current is then sufficient to operate relay "A," and this relay in operating allows the other relays to resume their normal positions.

When the variations in the pressure upon the transmitter diaphragm in either hand set varies the resistance of the corresponding branch circuit a slight variation in the current from the battery is produced. The internal resistance of the battery is sufficient to produce a slight variation in its terminal voltage. The resulting variations in the line voltage, and hence in the drop across the receivers, produce the usual vibrations in the receiver diaphragms. These variations also produce slight variations in the current through the primary winding of the induction coil, resulting in greater variations across the terminals of the secondary winding. Since the secondary winding is in series with the battery, the practical effect is to amplify the variations in the line voltage, and hence in the talking currents.

Successful working of the relays is obtained only by a careful adjustment of the screws which regulate the throw of the armatures. The relay "A" is located in front of the "+" battery post, the relay "C" in front of the "G" post.

In addition to the above matériel there are necessary for the mine system certain electrical instruments, as well as tools, appliances, and supplies requiring no special description, which are enumerated in the supply list. (Appendix 8.)

Figures 17a and 17b, at the end of the book, show the construction of an improvised mine target.

CHAPTER III.

LOADING ROOM DUTIES.

Making a telegraph joint.—The insulation is removed from the ends for 1½ inches and the wires brightened. The ends to be joined are placed across each other about one-third distance from the insulation, making an angle of about 45° with each other. The wires are grasped firmly at the junction and each free end wound tightly around the other wire for four turns; the winding should be in opposite directions. The ends of the wires are trimmed down so they will be smooth and present no sharp points.

When wires are joined with brass jointers three-fourths inch of each wire is bared and the wires are inserted in the jointer; each end is crimped with pliers in the direction of the longer axis; the rest of the jointer is crimped and the ends or sharp points rounded off. When brass jointers are used care should be exercised not to crimp them too hard, as the wires may be partly cut through and finally broken. Special care must be used with the fuse leads, as the secondary circuit of the mine transformer can not be tested after the compound plug is assembled.

Insulating a joint.—A piece of rubber tape about 2 inches long is used, with ends cut diagonally. The tape is stretched, and starting at a point about three-fourths inch back on the insulation, with the long edge of the tape on the inside, it is wound around the joint under tension, each turn covering the previous turn about one-third. The wrapping is continued until the same amount of insulation is covered on each side, when the wrapping is worked backward over the joint and the end is secured by pressing it firmly a short time or placing a drop of cement under it.

Making a water-tight joint.—The two ends of wire are scraped clean for about three-fourths of an inch and joined by a brass jointer, which is then crimped. The insulation is scraped clean about 2 inches on each side of the jointer and covered with rubber cement. (Cement is not absolutely essential.) Two strips of rubber tape are cut about 6 inches long, with diagonal ends, and stretched. Beginning about 1½ inches along the insulation, the tape, with the long edge on the inside, is wrapped firmly and tightly until about one-fourth of an inch of the insulation on the other side is covered; it is wound back and forth over the joint so as to taper toward the ends. The other piece of tape is used, beginning at the other end and wrapping as before. The finished insulation should be thick at the middle and taper toward the ends. It should be firm and tight. The insulation is covered with tin foil, wrapped with protective tape, and vulcanized for about 30 seconds. The protective tape and tin foil are then removed, the joint inspected, and new protective tape wrapped on, using two pieces, starting at opposite ends and finally ending each beyond the center.

Making a Turk's-head.—The cable is trimmed square and a wrapping of four or five turns of marline is made about 15 inches from the end. The collar, flat side first, is slipped on until it rests on the marline; the iron wires are bent back regularly over the collar. The jute wrapping is unwound to the collar and trimmed, and all the iron wires are cut with the pliers, removing all but 4 inches and 6 inches from alternate strands; the iron wires are bent separately to fit the collar closely (making two right angles with the pliers), and the ends arranged smoothly along the cable; the end of a piece of marline is engaged under one of the wires near the collar and wrapped regularly and closely around the cable, and the free end of marline secured with two half hitches. About 15 feet of marline are required for single conductor cable; 24 feet for multiple cable.

Testing fuses.—The following apparatus is used for testing in the loading room: A double-pole double-throw switch, a

150-volt voltmeter, and sufficient dry cells to give a full throw when using the lower scale of the voltmeter. The apparatus is connected up on the testing table so as to make resistance measurements by the voltmeter method. To test fuses, leads are carried from the switch to an iron or other suitable receptacle outside of the building and the fuse leads joined thereto. A full deflection should be obtained when the circuit is closed through the fuses.

Preparing a compound plug for service.—The transformer to be used is first tested for a good circuit between the red wires, a poor circuit between the ends of the black wire, a good circuit between the black or primary lead and the reactance terminal, no circuit between the red and black wires, and no circuit between any wire and the case. The resistance of the circuits is determined by the voltmeter method. The upper end of the black wire (see fig. 8) is prepared for use by baring the wire for about one-half inch and securing it to the binding post in the neck of the transformer. The ball seat is screwed home. The spring plate, distance ring, and ball are placed in the circuit-closer cap, which is held inverted and the transformer screwed into it, the threads being coated with ruberine.

(*a*) **Old model, brass fuse can.**—Starting with the compound plug dismantled.

A piece of loading wire is cut about 3 feet long and the ends bared. One end is joined by a telegraph joint to the primary terminal of the transformer and the joint is taped. This wire and the two secondary wires are drawn through the fuse can, which is screwed on the transformer, the threads of the latter having first been coated with ruberine.

Two mine service fuses, which have been tested for continuity of circuit, are connected in multiple across the secondary (red) terminals and the joints taped.

The can is held vertically and the explosive, if trotol, poured in up to the screw threads for the fuse-can cap; if dynamite, inclosed in a cloth bag and placed in the can. The fuses are embedded in the explosive.

The loading wire is drawn through a lead washer and the fuse-can cap; the latter, its threads having been coated with ruberine, is screwed into place.

A rubber packing is pushed over the loading wire into the stuffing box in the fuse-can cap, a brass gland is threaded down so that it is close against the rubber packing, and the follower in screwed home with moderate pressure. The lower tube is screwed into place, compressing a lead washer between it and the fuse-can cap. The threads of the follower and lower tube are coated with ruberine.

The loading wire is drawn through a lead washer and the hole in the plug proper, and the latter screwed hard against the lower tube.

A rubber packing and a brass gland are placed upon the loading wire and forced into their seat in the plug proper by means of the follower, the threads of which have been coated with ruberine.

(*b*) **Rubber fuse can.**—Starting with the compound plug dismantled.

Two mine service fuses, which have been tested for continuity of circuit, are cut with 9-inch leads, wires bared for about 1 inch and connected in multiple. A piece of loading wire is cut about 3 feet long and the ends bared for telegraph joints. It is threaded through a hole in a cake of dry gun-cotton. The two fuses are inserted by pushing each separately into the same hole and the loading wire drawn up until it is the same length above the cake as the fuse leads.

Three other primer cakes are threaded on the wire; two above the fuses, and one below. This arrangement will leave the fuses in the third cake. The cakes are held in one hand with the fuse leads upright, and the fuse can slipped over the cakes, being careful to thread the fuse leads and loading wire through the opening.

The screw threads of the fuse-can cap are covered with ruberine and it is screwed firmly into place onto the fuse can. The stuffing box of the cap is assembled.

The plug proper is held upright in a vise. The fuse can, the threads of the cap having been coated with ruberine, is

screwed home and secured by its set screw. The loading wire must be pulled through the opening in the plug proper with extreme care. It must not be injured in placing the fuse can in position and in screwing it home. The transformer leads are cut about 6 inches long, and the ends bared for 1 inch. The brass collar is screwed on the transformer; a little ruberine on the screw threads facilitates the operation. The connecting collar is slipped over the fuse leads and loading wire and allowed to rest on the fuse can. The transformer is supported by allowing two of the connecting bolts to slip into the holes in the collar; telegraph joints or brass jointers may be used between the secondary leads and the fuses and between the primary lead and the loading wire. The joints are wound with rubber tape, care being taken that there are no sharp ends to cut through the tape.

The transformer is raised vertically above the fuse can until the lead wires are extended. It is lowered and at the same time the leads are coiled in the base of the transformer. As the transformer and collar approach their position on the connecting bolts, the connecting collar is screwed on the transformer, the threads of the transformer having been covered wih ruberine. The connecting collar will take care of the remainder of the leads and joints. The set screw in the connecting collar is screwed home; the brass collar is placed on the connecting bolts and secured in position by the nuts and cotter pins.

The lips of the fuse can and connecting collar are covered with a thin covering of rubber cement. A piece of rubber tape is cut about 18 inches long and laid around this opening without stretching. A piece of protective tape is cut about 18 inches long and laid over the rubber tape with considerable stress. This forces the soft tape over the lips on the connecting collar and the fuse can and makes a tight but flexible joint. The stuffing box in the plug proper is prepared as under (*a*).

Great care must be taken not to injure the insulation of the loading wire in tightening up the follower in the stuffing box of the fuse can or of the plug proper.

(*c*) **Trotol fuse can.**—Starting with the compound plug dismantled.

Two mine service fuses, which have been tested for continuity of circuit, are cut with 12-inch leads, the wires bared for 1 inch and connected in multiple. A piece of loading wire is cut about 3 feet long and the ends bared for telegraph joints. The loading wire is threaded through the fuse can and cap. The threads of the fuse can are covered with ruberine. The can is screwed into the cap. The threads of the connecting collar are coated with ruberine and the collar is screwed down entirely. The loading wire should project about 4 inches above the connecting collar. The stuffing box of the cap is prepared. The plug proper is held upright in a vise. The fuse-can cap, its threads having been coated with ruberine, is screwed firmly into the plug proper by means of a spanner wrench. The loading wire must be pulled through the opening in the plug proper with extreme care. It must not be injured in placing the fuse can in position and screwing it home.

The fuses are inserted in the fuse can, which is filled with trotol to the top of the connecting collar. The transformer leads are cut 4 inches long and the ends bared for 1 inch. The threads of the brass collar are covered with ruberine. It is screwed on the transformer. The latter is raised vertically above the fuse can and lowered on the connecting bolts.

Telegraph joints are made between the secondary leads and the fuses and the primary lead and the loading wire. The joints are wound with rubber tape, care being taken that no sharp ends cut through the tape. The leads and joints are coiled in the base of the transformer. The connecting collar, its threads having been covered with ruberine, is screwed upon the transformer against the brass collar. The bolt-securing nuts and cotter pins are placed in position. The stuffing box in the plug proper is assembled as under (*a*).

The actual resistance of the assembled plug in the vertical and the horizontal positions is determined by testing with a voltmeter.

In service, after the loaded plug tests out satisfactorily, all set screws are set up.

When compound plugs are prepared for drill or for instruction purposes the use of ruberine or other waterproofing material on the screw threads is omitted; care must be taken that the transformer leads are not needlessly shortened.

Loading a mine.—The mine case is carried from the storeroom to the loading room and placed on a loading skid or other receptacle with the loading hole up. The plug is removed and the screw threads are thoroughly cleaned. The explosive detail brings in a box of explosive from the explosive house and inserts a loading funnel into the loading hole. The charge for a 32-inch mine case is 100 pounds of explosive. For the larger cases, the charge should be the maximum that the conditions warrant; it is specified at present as 200 pounds, though larger charges are desirable if enough explosive can be obtained and the excess buoyancy of the case will warrant the use of more than 200 pounds. The cartridges of dynamite, the trotol, or the blocks of guncotton are inserted by hand and so placed in the mine case that there will be ample room for inserting the compound plug. Only one box of explosive for each mine being loaded is brought into the loading room at one time. After the proper amount of explosive has been placed in the mine case the screw threads are thoroughly cleaned with button brushes and then coated with ruberine or other material to prevent access of water. The compound plug, with its screw threads similarly coated, is screwed home with the socket wrench, a lead washer being used between the plug and mine case. A bar put through holes in the sides of the skids and through the maneuvering ring will prevent the case from falling over and from turning while the compound plug is being screwed home.

In order to insure setting the compound plug tight, it is advisable to tap the end of the lever of the socket wrench a few times with a large mallet or a large wooden bar. The mine cap is bolted on and the mine put in a tank for test. If time admits, it may remain in the water 24 hours. It

should show practically the same resistance as the compound plug. If this test be made, the loading wire must be long enough for this purpose.

Upon completion of this test the mine is taken from the tank, the loading wire pushed inside the cap to avoid injury in handling, and the loaded mine taken to the planting wharf.

The precautions to be observed in handling explosives and loading mines are given in Appendix 1.

CHAPTER IV.

LOCATING DISTRIBUTION BOX, LAYING MULTIPLE CABLE, AND MARKING OUT MINE FIELD.

(NOTE.—The operations in Chapters IV and V are described in what is thought to be the logical order, but circumstances may alter their sequence, and, in fact, several of the steps may be carried on simultaneously.)

For the work on the water there will be needed five boats, viz, a mine planter or suitably fitted-up heavy tug, a small tug or heavy launch called the distribution-box boat, and three launches or yawls. The capacity of the planter is such that a group of 19 mines can be handled at one time.

The instructions to be observed by the master of a mine planter in marking out a mine field and in planting mines are to be found in Appendix No. 6.

Determining location for distribution box.—From an examination of the chart, or of the approved scheme for mining, the locations of the lines and groups of mines are determined. A distribution box is to be placed about 350 feet in rear of the center of each group of mines. The locations for the distribution boxes are marked on the plotting board and their azimuths from each of the ends of the horizontal base or their azimuth and range from the vertical base station are determined.

Marking location of distribution box.—An anchor with buoy attached is placed upon the deck of a small tug and carried out to one of the selected spots. By a system of signals the boat is directed to the location determined and there the anchor is thrown overboard. The locations for the other distribution boxes are marked in a like manner.

Laying multiple cable.—The cable reel is placed upon the forward deck of the planter and raised on the jacks. The

planter then proceeds as near the mining casemate as the depth of water permits, and one end of the cable is passed ashore, either by a launch, by yawls, or by any other suitable method. In case the planter can not approach nearer the shore than 100 yards it will be necessary to coil more than enough cable to reach the shore in a figure of eight in a yawl, which is then towed toward the desired point on shore, the men aboard the yawl paying out the cable as it proceeds. This end is drawn in through the conduit or gallery to the casemate or terminal hut. It may be secured by taking a telegraph hitch around it with a chain and spiking the chain to some heavy timbers or fastening it to some holdfast. When cable ends have already been laid they will be picked up and joined to the multiple cable for the groups.

The shore end having been secured, the planter moves out to the position of the distribution box, unreeling the cable as it goes. If the water be very deep, a friction brake must be extemporized to prevent the reel from overrunning. (While the planter is laying the cable, the casemate party tags and attaches the shore end as explained later.) To prevent kinks as far as possible cable should be laid with as much tension as practicable.

If the cable is not long enough, a second one must be joined to it. This is preferably done by passing the ends to a small boat. The junction is made, either using a junction box with Turk's-heads and taped joints, or opening back the armor for about 5 feet from the ends, making taped joints, protecting them with tape, and then rewrapping the armor and seizing the ends with wire. Care must be taken to join the proper conductors of the two ends.

In the meantime the distribution-box boat with a detachment of one noncommissioned officer and five men takes the distribution box and moves out to the spot marked by the buoy. It picks up the buoy and makes fast to the anchor line.

The planter continues laying the multiple cable until it reaches the distribution-box boat. The multiple cable is then cut and the end passed to the distribution-box boat, usually by a heaving line. The cable is lashed to the boat; a Turk's-

head is worked upon the end and then secured in the distribution box. As a precautionary measure for the recovery of the distribution box, should it be lost overboard during mine planting, it is well to have the multiple cable buoyed about 100 yards in rear of the distribution box.

In case it may be desired not to use the distribution box at once, the separate conductors of the multiple cable should be tagged, tested, and insulated. The cable should be buoyed and dropped overboard to be recovered subsequently.

Identifying, tagging, and testing the conductors of the multiple cable.—*Tagging.*—In the casemate the conductors are separated, carefully identified, tagged, and attached to the corresponding terminal of the terminal bar on the operating board. The mine switch for No. 19 is opened and the telephone terminal attached to its stud so as to use No. 19 for communicating with the distribution-box boat. The ends in the distribution-box boat are separated, one terminal of a boat telephone is attached to No. 19, and the other earthed either by attaching to the cable armor or to an earth plate hanging overboard in the water. Communication is thus established with the operator in the casemate. Nos. 1, 13, and 19 are picked out easily; the remaining ones are tagged in contra-clockwise direction.

Verifying the tagging.—The casemate is then notified that the boat party is ready to check the tagging. This is done as follows: The power switches on the operating board are all closed, except 19, and direct current put on the cable by closing switch No. 3 up. The casemate operator then directs the boat party to earth in regular succession the various conductors. This is done most quickly by touching the conductor to the cable armor. The corresponding automatic switch on the operating board should drop. Any errors in tagging detected by this test should be corrected at once. This test also checks the continuity of circuit of each conductor.

Insulation test.—The operator then directs the boat party to prepare the cable end for insulation test. This is done by separating the conductors, holding them in the air, and drying them if necessary.

When prepared, word is sent to the casemate operator, who tests as follows: He closes switch No. 7 up. This throws D. C. power on the mil-ammeter plug of the operating board and introduces in the circuit the mil-ammeter and its protective lamp. The green lamp is then unscrewed and the mil-ammeter plug used on the D. C. jaw.

If there be no leak in the multiple cable, since the ends at the distribution-box boat are held in the air, there will be no appreciable reading of the mil-ammeter.

If there be a leak, this fact will be revealed by a reading on the mil-ammeter. To discover the particular conductor or conductors on which this leak exists, each power switch is opened in succession and the mil-ammeter plug inserted on the jaw of the power switch.

No. 19 is now tested in the same way by first shifting both telephones to No. 1, the boat end being held in the air. The operator reports the result of the test.

Upon completion of these tests the power is turned off. Post power should not be used for testing, because the negative side of the post power may be grounded.

Marking out the mine field.—In using automatic anchors it is not necessary to mark the mine field; but in using mushroom anchors it is generally done. The material required consists of 1 measuring line with reel and frame, 5 anchors, 5 keg buoys, and 5 raising ropes.

A buoyed anchor is dropped about 350 feet in front of the distribution-box buoy. This marks the position of mine No. 10 and of the center of the group.

This marking buoy is picked up by a launch which makes fast to the anchor rope. The planter now passes to the launch one end of a measuring line, which has marks at 280, 300, 350, 580, and 600 feet. These marks may be made by painting 3 feet of the measuring line some distinctive color at the designated points. The planter moves out slowly along the line to be occupied by the mines, unreeling the measuring line as it goes, and drops buoys at the 300 and 600 foot marks. It then returns and does the same for the other side of the line. These five buoys mark the line to be

occupied by the mines, indicate the positions of mines Nos. 4, 7, 10, 13, and 16, and in addition cut up the distance into 300-foot lengths, which enable the planter to plant mines at a close approximation to 100 feet apart.

Taking soundings on line of mines.—When automatic anchors are used, such information as may be required about depth of water may usually be obtained from charts. This may not be sufficiently accurate for planting with ordinary anchors. In the latter case soundings must be taken at the spots where the mines are to be planted.

These soundings are made from the launches. The launches take a measuring line marked at every 100 feet, stretch it between the planted buoys, and take the soundings at every 100-foot point. The soundings are recorded in a blank book showing the number of the corresponding mine and state of the tide. It may be found more satisfactory to hold one end of the measuring line at the buoy and circle across the line of mines with the launch, getting the sounding at the point of crossing.

Preparing mooring ropes.—The mooring ropes are cut off with square ends, and the ends passed through the holes in the mooring sockets. The strands and wires are untwisted and spread out for a length equal to the length of the socket hole. The rope is pulled back until the ends are about flush with the top ends of the hole; a piece of marline is tied about the rope below the socket. If necessary to hold the socket, a piece of burlap may be wrapped around below the socket, and a fold allowed to fall over the hand. Generally, means can be found to set the socket upright while pouring full of alloy. The alloy consists of 9 parts of lead and 1 part of antimony melted together. A melting pot heated by a plumber's furnace, or preferably a Khotal lamp, is used for this purpose. Great care must be taken to see that there is no oil or water on the socket or mooring rope before pouring the alloy.

The length of the mooring rope for buoyant mines No. 32 equals the depth at low tide, less 15 feet. This allows 5 feet

for the length of the mine, anchor, and shackles, and 10 feet for submergence. When thimbles and clips are used the mooring rope is cut 3 feet longer and is bent back a foot and a half at each end for the thimbles and clips.

For the larger mine cases, an additional allowance must be made for the length of the cylindrical part of the case.

Each mooring rope is carefully tagged at each end with the number of the corresponding mine.

CHAPTER V.

ASSEMBLING AND PLANTING MINES.

NOTE.—The instructions to be observed by the master of a mine planter in marking out a mine field and in planting mines are to be found in Appendix No. 6.

The planter detail.—This consists of the chief planter and 3 noncommissioned officers and 16 privates, distributed in three details, as follows: One noncommissioned officer and six privates on each side of the planter and one noncommissioned officer and four privates aft.

Tools and supplies.—The tools and supplies to be taken aboard for the work described are:

On the planter.	On distribution-box boat.	In each yawl.
Alcohol.	Alcohol.	Anchor, boat.
Anchors.	Anchors, boat (2).	Anchor line.
Axe.	Axe.	Boat hook.
Boat hooks.	Boat hook.	Heaving line.
Buoy, key.	Boat telephone with connectors and earth plate.	Life buoy.
Buoys, mine.	Breaker of drinking water.	Life preservers, 1 for each man.
Cable cutter.	Buoy.	Marline.
Cables, multiple.	Cable tags.	Megaphone.
Cables, single conductor.	Compass, boat.	Oars and locks (7).
Cable tags.	Distribution box.	Sounding line.
Clips, cable.	Flags, boat (2).	
Cotter pins.	Gasoline (tankful).	
Crank handle for automatic anchor.	Green light.	
Dry cells.	Hammers.	
Grappling hooks.	Heaving lines.	
Hammers.	Kerosene.	
Heaving lines.	Knives, submarine-mine.	
Kerosene.	Lamps, alcohol (2).	
Knives, submarine-mine.	Lashings.	
Lamps, alcohol (2).	Life buoys (2).	
Life buoys (3).	Life preservers, one for each man.	
Marline.	Marline.	
Marlinespikes.	Marlinespike.	
Matches.	Matches.	
Megaphone.	Megaphone.	
Mines.	Monkey wrenches.	
Monkey wrenches.	Notebook and pencil.	
Nuts.	Red light.	
Ropes, mooring.	Rope, raising.	
Ropes, raising.	Ropes, buoy (2).	
Shackles, anchor.	Shackles.	
Shackles, mine.	Tools and materials to make Turk's-heads and joints.	
Shoes, mine-cap.	Waste.	
Sister hooks.	White lights (2).	
Spring balance.		
Stamping outfit.		
Tools and materials necessary to make Turk's-heads and joints.		
Voltmeter.		
Washers.		
Waste.		
Wire, soft-drawn copper.		
Wrench, socket, for automatic anchor.		

Preparing mine cables.—A reel of single-conductor cable is taken from the tank and placed on a cable-reel frame. A piece 20 feet long is cut off the end to eliminate the part which was above water during storage. The cable for the mines is now unreeled, cut to the following lengths *plus twice the approximate depth of the water*, and each end carefully tagged with the number of the corresponding mine. A Turk's-head is made on each end.

	Feet.		Feet.
No. 1	1,425	No. 11	425
No. 2	1,225	No. 12	475
No. 3	1,025	No. 13	525
No. 4	825	No. 14	625
No. 5	725	No. 15	725
No. 6	625	No. 16	825
No. 7	525	No. 17	1,025
No. 8	475	No. 18	1,225
No. 9	425	No. 19	1,425
No. 10	375		

The mine cables are coiled in figure 8's. In order to secure uniformity in the size of the coils, they may be coiled on a rack (improvised at the post). This rack is made of one 12-foot length of 4 by 6-inch scantling, crossed at right angles by two 6-foot lengths (4 by 6 inch) placed 5 feet apart. Four 1-inch holes are bored through each of the timbers about 2 feet from each of the crossings, and a 2-foot length of gas pipe is inserted in each hole. These pipes make the form on which the coils are made.

A cable must be coiled for planting so that both ends are free, one to be passed to the distribution-box boat, the other to be carried forward on the planter and attached to the mine. This is accomplished by starting the coil about 135 feet from the mine-cap end, the approximate length required to run forward when using a mine planter. The cable is coiled on the form, spreading out the laps at the center to reduce the height at that point, until the entire length is coiled. The outer loops and the center of the figure 8 coil are lashed, leaving the ends sufficiently long to lash the part of the cable

remaining uncoiled. The mine-cap end of the cable is then coiled on top of the coil and lashed with the ends of the rope.

Single-conductor cables when coiled should be tested for continuity of circuit and grounds before being placed aboard the planter.

For continuity of circuit the two ends of the cable are connected to a battery and voltmeter in series. If the cable has no break, the reading of the voltmeter should show approximately the same deflection as when the battery circuit and voltmeter alone are in circuit.

To test for a ground the cable is submerged in a testing tank, leaving both ends out. It is advisable, when practicable, to extend a lead from one of the operating boards of the mining casemate to the cable tank. One end of the cable to be tested is connected to this lead and the test made as prescribed for "insulation test" on page 44. The condition of a multiple-conductor cable can be quickly determined by this arrangement. If the above method is not practicable, a dry-cell battery with a mil-ammeter and protective lamp may be installed at the cable tank; or, in place of the mil-ammeter and lamp, a voltmeter placed in series with the battery and cable may be used, the resistance being obtained by the voltmeter method. One side of the battery should be grounded by touching the cable armor or by using an earth plate. In actual service, cable which tests under 1 megohm should not be used; for practice, cable under 10,000 ohms should not be used. If post power is used as a source of energy for testing, the system should be free from grounds. Care should be taken to have the cable ends and battery leads free from grounds and dry.

Cables are raised and lowered into the tank by means of a cable yoke, which consists of an 11-foot length of 4 by 6 inch scantling, with three hooks on the lower side and a ring on the upper side at the center for hoisting. The lower hooks, which are secured to the scantling by a bolt and ring, hook into the lashing on the cable. Washers are placed under the bolt heads to prevent their slipping through the holes.

Swinging or traveling cranes with triplex blocks are used for lowering and raising cable and yoke.

The coils of single-conductor cable are carried aboard the planter, to the aft deck, by the cable detail, or they may be lowered onto the deck by means of the cable yoke and a derrick on the wharf. The cable for mine No. 1 is placed on the starboard side of the aft deck and its mine-cap end is carried forward on the cable racks close to the mines. The other cables, Nos. 2 to 9, inclusive, are placed in succession on the starboard side in the same manner. The cables, Nos. 19 to 10 are placed in succession on the port side, with No. 19 at the bottom. The coils on each side are placed on top of each other. The cable should be removed from the racks when its corresponding mine is being prepared for planting.

At the same time the other apparatus and appliances are carried aboard and placed forward, the proper supply on each side. The anchors are placed as convenient to the forward davits as possible.

Finally, the loaded mines are put aboard. If they contain dynamite they should be protected from the direct rays of the sun by being covered with a paulin.

Preparing mines for planting.—The detail on each side of the planter prepares a mine on its own side. The loading wire from the mine is cut to the proper length, a water-tight joint is made with the single conductor of the corresponding cable, and the Turk's-head is clamped in place, care being exercised that no part of the leading-in wire is caught under the clamp. The cable is lashed with soft-drawn copper wire or secured by clips to the bails just above the ring.

The proper mooring rope is now shackled at one end to an anchor, at the other end to the mine, and is lashed to the mine cable with soft-drawn copper wire at every 5 feet. If automatic anchors be used, the mooring rope is shackled to the mine after the anchor and mine are swung outboard; the lashing of the cable to the mooring rope is omitted.

A rope for raising the mine is cut to the length of 80 feet plus the depth of water. One end is attached to the anchor by an anchor knot or bowline, the other to the mine cable by

two half hitches and a seizing of soft-drawn copper wire. It should not be secured at other points.

The mine buoys have attached to them 60 feet of ½-inch rope, which is marked at every 5 feet. The free end is slipped through the maneuvering ring of the mine and tied to the buoy.

When planting mines for practice, marline may be used to seize the raising rope to the cable and to lash the cable to the bail and mooring rope.

A mousing must be put around the upper hook of the differential block to prevent the block from jumping off the hook when the mine or anchor is tripped. The tripping hook of the differential block on the forward davit is attached to the anchor and it is hoisted and swung outboard clear of the rail. The mine is similarly slung from the after davit by its maneuvering ring or by a rope sling through the latter. Both mine and anchor are lowered as close to the water as conditions will permit. A heaving line is bent onto the free end of the mine cable, generally by means of a clove hitch and two half hitches.

The aft detail now removes or cuts the rope lashings of the coil of the corresponding mine cable. A detail sees that the cable and raising rope are held on the gunwale ready for planting. These should not be allowed to trail in the water. A man stands near the mine davit ready to throw the mine buoy clear of the planter when the mine is tripped. (Fig. 13 shows the mine and anchor slung for planting and fig. 14 shows the relative position of the various parts in the water. In these figures the cable should be shown as lashed to the mooring rope.)

The distribution-box boat should precede the planter to the mine field. The distribution-box buoy, to which the anchor rope is fastened by a bowline, to the bight of which the raising rope is secured, is taken aboard at the bow, if the tide is coming in toward the box, and the anchor rope is made fast. The distribution box is then raised by its raising rope and secured in the stern. The boat is thus anchored fore and aft, perpendicular to the line of mines, with its bow pointed toward the position of the center mine of the group. If the tide is running out from the box, the buoy should be taken

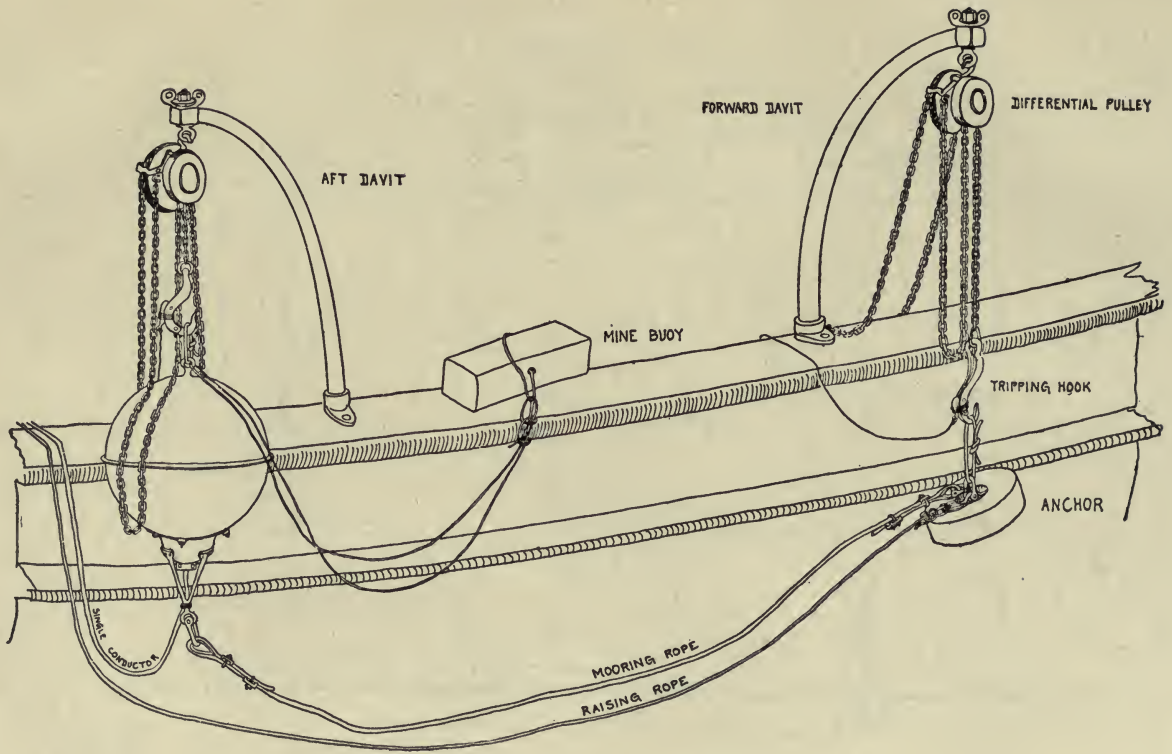


FIG. 13—MINE READY FOR PLANTING.

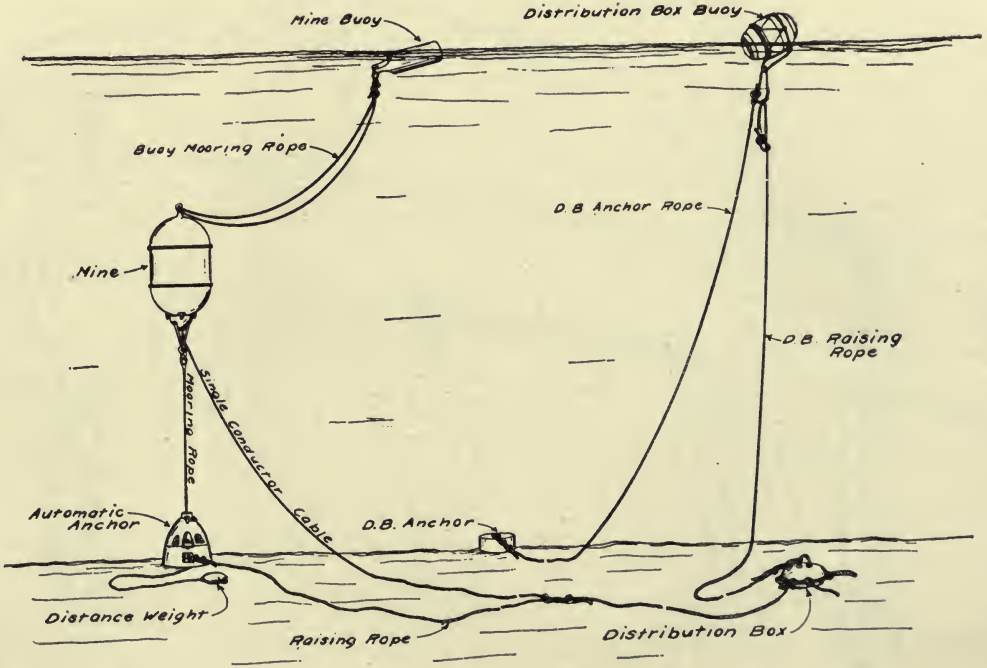


FIG. 14.—MINE PLANTED.

in at the stern, the boat being held in position by the raising rope of the distribution box and then by the multiple cable. The anchor rope is finally made fast in the bow. During the planting of mines a man should always stand ready to slacken away on the anchor rope if necessary.

If the buoy for the distribution box is not in place, the cable must be underrun, either from shore or from a buoy planted for this purpose. This is done preferably with a yawl. The cable is raised, taken aboard, and placed over a roller or rowlock in the stern. The cable is then pulled in over the stern and lowered over a roller or rowlock in the bow. If the planter is to underrun cable, a cathead is put in place and a snatch block is lowered by a raising rope secured to a hoisting windlass. The cable is placed in the snatch block and the planter moves forward slowly. When it is desired to transfer the cable to a small boat the snatch block is lowered into the boat and the cable removed.

After the distribution-box boat has secured the box in position, the lid is removed and the cable is tested as prescribed on page 44. A signal is then raised to indicate to the planter that the distribution-box boat is ready for the planting of mines.

Planting the mines.—If there be a strong tide, the mines should, if possible, be planted at such time that the planter, in going out toward the line of mines, moves against the tide.

The planter moves out and passes close to the distribution-box boat, with the latter to port. As it passes slowly by, a heaving line is thrown by a man forward of the beam to the distribution-box boat, whose party immediately hauls in the mine cable, bends on another heaving line, and lashes the cable to the boat. It is desirable to have a second heaving line ready in case the first one fails. If the water be rough the cable end is passed to the boat by a launch.

The planter moves forward to the position to be occupied by mine No. 10. If automatic anchors are used, the distance weight is lowered at the command "Lower weight," given after the cable is secured in the distribution-box boat. As the planter approaches this position the command "Get

ready" is given. As the forward davit comes abreast of the position of No. 10 mine, the officer in charge of the planting commands "Let go"; the tripping hook of the mine is released first and that of the anchor immediately thereafter. The mine buoy, cable, and raising rope are then thrown overboard.

(Caution.—The men operating the tripping hooks must be very careful that they stand back of all cable and rope, so that they may not be caught. All others must stand clear.)

The planter turns so that the stern will be thrown away from the planted mine. When the stern is clear of the mine buoy "All clear" is signaled from the stern.

The planter then executes a sweeping circle to starboard, passes to the rear, and comes up with the distribution-box boat to starboard. As it moves by, the free end of mine cable No. 9 is passed to the boat and secured as before. The planter moves ahead to a point 100 feet to the left of mine No. 10, and as it crosses the line, plants mine No. 9, swings off to port, circles and comes up from the rear with the distribution box to port, and so on alternately until all the mines are planted.

As soon as a mine is dropped the detail for that side of the planter prepares another for planting. There is ample time to do this while the vessel is turning and planting the other mine.

Two small boats, one on each side of the line, work as follows: As soon as a mine is dropped the boat on the corresponding side moves to it, picks up the buoy, pulls the rope taut, notes the submergence of the mine, transmits the data to the planter, and holds up an oar or a flag in prolongation of the buoy rope. The observers at the ends of the base line take observations on this marker and are thus able to plot the position of the mine accurately. This process is repeated for each mine.

These boats also serve as guides to the planter in dropping mines by holding on to their buoys until the adjacent mines are planted. With automatic anchors the line may not be marked otherwise than in this manner.

After the mine is dropped, the members of the distribution-box boat party remove the lashing from the cable, insert the Turk's-head in the proper slot, make a temporary joint between it and the corresponding conductor of the multiple cable, and telephone to the casemate operator. The latter opens all the power switches on the corresponding operating board, closes switch No. 7 up (this throws D. C. power on the mil-ammeter lead), and then plugs in on the upper jaw of the power switch of the mine under test. If the D. C. voltage be 110, the mil-ammeter should read about 40 mil-amperes; if the voltage be 80, the reading should be about 30. If this test be satisfactory, the joint is made permanent.

For the last mine the telephones are removed from the corresponding conductor, a temporary joint is made in the boat, and the test made as above. By arrangement with the casemate operator the mine is left on two minutes for test. At the end of this time the joint is opened and the telephones put back. If the casemate operator reports the test satisfactory, the telephones are again removed and a permanent joint is made.

When the last joint has been made, the distribution box is closed and the raising rope fastened to its lid. The box is then lowered. This is done by the distribution-box boat if it is provided with the necessary davit and power, otherwise it is done by the planter. Generally the anchor rope is made fast to a buoy by a bowline, and the raising rope of the distribution box is secured to the bight of the bowline.

After the distribution box is lowered all buoys are removed except that for the box, and such others as it may be desired to place for marking the ends of lines. The marking boats may remove the mine buoys as they work, provided they are notified from the mine commander's station that proper observations for plotting have been obtained. Such notification is usually sent by telephone to the distribution-box boat.

In time of war decoy buoys judiciously placed would be very useful in deceiving the enemy.

CHAPTER VI.

TESTS OF MINES AND APPARATUS.

After the mines have been planted the following tests are made daily, or more frequently if need be, the results being recorded carefully on the form given at the end of the chapter. (Note: This applies also to such test mines as may be kept planted for purposes of observation and instruction.)

Caution.—If A. C. power be supplied from the casemate motor-generator, there is no possibility of accidental firing of mines if the motor-generator is not running; and when it is running the chance is remote, since it would require the committing of three blunders. However, the following precautions must be enforced rigidly:

(*a*) *Never start the motor-generator during the planting of mines nor when any friendly vessels are in the neighborhood of the mine field.*

(*b*) *Before starting the motor-generator for testing it, see that all automatic switches are up, all firing switches open, and the A. C. operating switch (No. 8 of the power panel) open.*

1. **Test of the D. C. voltage.**—Plug in at the proper receptacle and read the voltmeter.

2. **Test of the A. C. voltage.**—*Caution.—First see that all automatic switches are up, that the firing switches are open, and that the A. C. operating switch No. 8 is open.*

Close switch No. 4 up; close starting switch of motor-generator, and when the latter has attained its full speed close switch No. 9 up; plug in at the proper receptacle, and read the voltmeter. When the source of power is the storage battery, the battery rheostat should be adjusted until the A. C. voltage is 500 or above; when the casemate generator is used, its field rheostat should be adjusted for the same purpose.

3. Test of the mines.—Leakage in mine circuits will be indicated automatically by an increased brightness of the green lamp on the signal block; an excessive leakage in any mine circuit may cause the automatic switch to trip.

However, each mine should be tested separately, as follows:

With the D. C. on the D. C. busses of the power panel, close switch 7 up, open the power switch on the mine block of the mine circuit to be tested, and put the M–AM " plug " on the upper point of the power switch. If the automatic switch falls, adjust the solenoid or hold the switch up while testing the circuit, otherwise the reading obtained will be that of the red lamp and bell circuit. These operations put the mil-ammeter and its protective lamp in series with the mine circuit.

The circuit is as follows: From the negative D. C. bus on the power panel, to switch 7 closed up, through the mil-ammeter and its protective lamp, to the terminal bar, to the M–AM lead, to the plug, to the upper point of the power switch P, through the solenoid, to the middle of the testing switch T, to the upper point of same, to the upper point of the automatic switch, to the middle of same, to the mine switch, through same, to the terminal bar, through the 19-conductor and the single-conductor cables, to the mine transformer primary, to the mine case, to ground, to the D. C. " earth " terminal on the power panel, to switch 7, and to the positive D. C. bus on the power panel.

With from 80 to 110 volts these readings should normally be between 30 and 40 mil-amperes. A mine may be fired if the reading with 80 volts is between 14 and 120 mil-amperes. These limits increase with the testing voltage. If the mine tests within the firing limits, the solenoid should be adjusted if the current is above its normal setting (0.075 amperes). If the test indicates that the mine can not be fired, the mine switch should be opened.

4. Test of the automatic switch, red lamp, and bell.—Throw the D. C. power on the busses of the operating board by closing switch 3 up. Open the bell switch. Next close the testing switch down on the mine block under test. The red

lamp should glow and the corresponding automatic switch trip. (For circuit see fig. 18.) Now close the bell switch, throwing the bell in parallel with the red lamp; the bell should ring. Next open the bell switch and repeat the test for each mine block in turn.

5. **Test of the alternating circuit.**—This circuit is tested with D. C., as follows: Connect the A. C. and D. C. jaws on the master block with a jumper, open the power switches, close switches 3, 8, and 9 up on the power panel. The green and white lamps of the operating board under test should glow. A break or an excessive resistance in the casemate grounds, or elsewhere in the circuit, will be indicated by the lamps not glowing, or glowing dimly.

The circuit is as follows: From the negative D. C. bus on the power panel, to switch 3, to the "operating board" terminal, to the D. C. lead, to the D. C. post on the signal block, through the green lamp, to the D. C. jaw on the master block, through the jumper, to the A. C. jaw on the master block, through the white lamp and resistance in parallel, to the A. C. post on the signal block, to the A. C. lead, to the A. C. "operating board" terminal, to switch 8, to the A. C. bus, to switch 9, to the casemate transformer secondary, back to switch 9, to the other A. C. bus, back to switch 8, to the A. C. earth, through ground, to the D. C. earth, to switch 3, and to the positive D. C. bus on the power panel. With this circuit on, remove the 90-ohm resistance in parallel with the white lamp; the white lamp should glow more brightly, indicating continuity of circuit through the resistance as well as the white lamp.

It will be observed that the above test is for only a part of the A. C. circuit. To test the firing switch and the lower contact of the automatic switch, open switches 3, 8, and 9, close 7 up, remove the jumper, put the M–AM "plug" on the A. C. jaw on the master block, close the firing switch, and trip in turn each automatic switch by raising the corresponding knob on the solenoid and observe the reading of the mil-ammeter. Close each automatic switch up before tripping the next one.

The mil-ammeter reading should be from 30 to 40 mil-amperes, indicating a circuit through the firing switch and the automatic switch. The circuit is as follows: From the negative D. C. bus on the power panel, to switch 7 closed up, through the mil-ammeter and its protective lamp, to the operating board terminal, to the M–AM lead, to the " plug," to the A. C. jaw on the master block, through the firing switch F. S., to the A. C. bus on the operating board, to the lower point of the automatic switch which was tripped, to the middle of same, to the mine switch, through the same, to the terminal bar, through the 19-conductor and the single-conductor cables, to the mine transformer primary, to the mine case, to ground, to the D. C. " earth " post on the power panel, to switch 7, to the positive D. C. bus on the power panel.

6. **Test of the delivery of the A. C. power to the operating board.**—*See that all the automatic switches of the operating boards are up and all the firing switches of the master blocks open.* Close switches 4 and 9 up (or down) and 8 down; close the testing switch T. S. on the master block. The white lamp should glow and the A. C. bus-bar voltage should drop appreciably.

The circuit is as follows: From the A. C. bus on the power panel, to the lower right terminal of switch 8, to the " operating board " terminal, to the A. C. lead, to the A. C. post on the signal block, to the white lamp and the resistance in parallel, to the A. C. jaw on the master block, to the testing switch T. S., to the " earth " post on the signal block, to the earth lead, to the D. C. earth, through earth, to the A. C. earth terminal on the power panel, through the choke coil, to switch 8, to the other A. C. bus on the power panel.

In this test it is imperative to see that all the automatic switches are *up* and all the firing switches are *open.*

7. **Test of the power.**—Insert two fuses in multiple across the fuse leads from the power panel. Put the fuses in a place prepared for the purpose outside of the casemate, so that there will be no danger from flying fragments. With all the switches on the power panel open, all the automatic switches

up, and the firing switches on the master blocks open, energize the D. C. busses of the power panel, close switch No. 4 up (or down), and close the starting switch; close switch No. 9 up (or down); close switch No. 12 up (which connects the mine transformer secondary to the fuses); and, finally, close switch No. 11 up (which throws the A. C. power on the mine transformer primary). The fuses should explode.

If fuses are not available for this test, a low-voltage lamp or a short piece of fine wire may be heated to incandescence.

8. **Test of grounds.**—(*a*) "Separate" grounds shall be made for the A. C. power and the D. C. power on the power panel. The word "separate" as here used means actual connection to earth without metallic contact of the earth leads. A convenient method of making a ground is to connect to the armor of a cable running to salt water, a bond being made in case the armor of the cable in the casemate does not reach water before a joint is made. If a cable armor is used for one ground, the other ground lead must go to earth without contact with that armor. This may be accomplished by using the conductors of a cable, the ends of which are grounded to an earth plate in salt water.

(*b*) Neither of the grounds made should have more than 10 ohms resistance. To verify this, tests should be made as follows:

Close the double circuit breaker; close switch 7 up and plug the extension cord of the mil-ammeter lead of the power panel on the upper left-hand terminal of switch 8, the mil-ammeter extension cords for the operating boards being disconnected.

Ascertain the voltage across the mil-ammeter and lamp, and across the bus bars. Read the mil-ammeter.

From these readings the combined resistance of the grounds can be determined.

A table or chart may be prepared giving the resistances for various testing voltages and mil-ammeter readings.

Form for record of tests, Group No.

| Date. | | |

CHAPTER VII.

TAKING UP MINES.

Mines should be raised in the reverse order from that in which they were planted if the conditions of wind and tide are favorable. With a cross tide or a strong cross wind, the mines should be taken up in regular order from one side so that the planter will not drift onto the mine field.

A yawl or launch takes position at the outer mine on each side. The mine-buoy rope is hauled up taut in order to locate the exact position of the mine. The boat holds fast until directed from the planter to let go. While the anchor and mine are being taken aboard the planter, the boat remains off the bow to render assistance if necessary.

The distribution box is raised by underrunning the multiple cable, or by means of its raising rope if the buoy has not been removed. The box is taken aboard the distribution-box boat, the lid is removed, and the mine cables, in turn, disconnected from the multiple cable. The planter passes close to the distribution-box boat. A heaving line which has been made fast to the outer mine cable is thrown to the bow of the planter. If this should fail, a man throws a heaving line from the bow of the planter. If the conditions be unfavorable for passing a heaving line, a launch may carry the line to the planter. The heaving line attached to the cable is hauled aboard and the cable placed over the cathead. The planter then proceeds to underrun the cable. If the water be shallow, the cable is carried through a snatchblock to the aft deck and coiled, or it may be carried to a cable reel forward. If the water be deep, or the cable can not be raised easily by hand, it is carried through a snatchblock to the drum of a hoisting windlass and coiled as before mentioned.

(If placed on a cable reel, the ends should be insulated and tagged. Mine cables Nos. 1 to 9 should be placed on one reel and Nos. 10 to 19 on another, both reels being carefully marked.) When the raising rope is reached, it is carried with the cable over the cathead. The bight of the rope is hauled in quickly, carried through a snatchblock, and a few turns taken on the drum of a hoisting windlass. The rope is untied from the cable as soon as possible. If there be danger of losing the rope, it should be made fast at once. The anchor is raised until within a few feet of the cathead. It is lifted aboard by means of the boom, or by the differential block on the anchor davit.

At the same time a man is sent over the side of the planter near the mine davit (a rope ladder may be used) to secure the hook of the differential block in the sling attached to the maneuvering ring of the mine when it comes to the surface. To bring the mine to the proper place to accomplish this, a man should be ready to secure the mine-buoy rope with a boathook; other men should be ready to pull the mine forward, if necessary, by means of the cable. The mine is raised by the differential block of the mine davit. It may be raised by the boom and fall; or by means of a tackle secured to the mine davit, the end of the rope running through a snatchblock to the drum of a windlass. The distance weight of the automatic anchor may be raised by the fall of the boom, or by an improvised tackle. An eye should be made in the distance rope for this purpose.

If the end of the cable is lost, the work may proceed as follows: The planter moves out to the mine if its buoy is still in place. A sling made of raising rope may be thrown over the mine, or two raising ropes are tied together and one end is passed to a launch which moves around the mine and brings the end back to the planter. Both ends are placed over the cathead, through a snatchblock, and around the drum of a hoisting windlass. The mine is hoisted, bail up, until near the cathead. It can then be transferred to the anchor davit. The mine cable is pulled in until the raising rope is reached. The work then proceeds as before. If the

mine buoy has been removed, a yawl may drag for the cable with a grappling iron. If the raising rope should break or be lost, the mine may be raised as mentioned above, except that the mine must be transferred to the fall of the boom and the anchor raised by means of its mooring rope, or the mine may be transferred to the anchor davit, as before, and a raising rope made fast to the mooring rope of the anchor and carried over the cathead, through a snatchblock, to a hoisting windlass. The mine, as soon as the strain is taken up by the raising rope, is unshackled. The anchor is then taken aboard in the usual manner.

As soon as the mines are taken aboard they are disconnected, the ropes are coiled, and all matériel placed so as not to interfere with subsequent work. As soon as the matériel is unloaded on the wharf it should be cleaned thoroughly and stored.

If the multiple cable is to be left down, the ends of the conductors are insulated, the lid replaced, and the box lowered by means of a raising rope, the end of which is made fast to the bight of the bowline of the anchor rope.

If the multiple cable is to be taken up, the end is passed to the planter, run through a large snatchblock on the bow, and coiled on a cable reel as it is raised. Whenever a multiple cable is coiled on a reel it should be secured so that both ends will be available for test when the cable is stored.

Unloading mines.—Should any of the mines be loaded with dynamite the utmost care must be exercised in unloading them. (See p. 76.) Some contrivance must be rigged up so that the first few turns of the compound plug may be accomplished by the operator at a distance, as there is great liability of explosion, due to leakage of nitroglycerin into the screw threads. After the compound plug is removed the precautions to be observed are given in Appendix No. 1.

Should the mine be loaded with guncotton or trotol, no danger is to be apprehended in unloading; the usual precautions in handling high explosives must, of course, be observed.

CHAPTER VIII.

THE MINE COMMAND.

A mine command consists of the mine groups and rapid-fire batteries specifically assigned for their protection, which are controlled by a single individual.

The mine commander is in direct command of the elements of the mine defense during drill and action. His station is at the mine primary, which is connected by telephone to the battle commander's station. He bears the same relation to the battle commander as do the fire commanders, and his duties are similar to theirs.

The mine commander is responsible that the property officer requests for all matériel necessary to carry out the approved scheme for mining the harbor; he is responsible, further, that the property officer keeps this matériel in proper condition for immediate service.

The senior company officer of the mine command is the property officer and obtains from the district artillery engineer all necessary matériel for the mine defense. He has direct charge of the storeroom, cable tanks, loading room, wharves, boats, boathouses, and mining casemate. The personnel of the mine companies are subject to his orders for service in connection with caring for and maintaining this matériel.

The officers of the companies of the mine command will be assigned by the mine commander in accordance with their special fitness.

The enlisted personnel of mine companies will be divided into sections, detachments, and details, as follows:

(*a*) Fire-control and power section.
(*b*) Planting and loading section.
(*c*) Gun and ammunition sections.
(*d*) Reserve section.

These will be subdivided as follows:

(*a*) Fire-control and power section:
  1. Observing detachment—
     a. M′ detail.
     b. M″ detail.
     c. M‴ detail.
  2. Plotting detachment—
     a. Plotting-board detail.
     b. Communication detail.
  3. Power detachment—
     a. Casemate detail.
     b. Searchlight detail.

(*b*) Planting and loading section:
  1. Planting detachment—
     a. Planter detail.
     b. Small-boat details.
  2. Loading detachment—
     a. Loading-room detail.
     b. Explosive detail.
     c. Cable detail.

(*c*) Gun and ammunition section:
  a. Gun details.
  b. Projectile detail.
  c. Powder detail.

(*d*) Reserve section: As required.

In each company assigned to the mine defense, a permanent manning table will be made out and always kept up to date. A copy of this manning table will be posted in the mine commander's station. In addition, a copy of such portion of this table as pertains to any particular station will be posted therein.

Plotting board.—The plotting board differs from that used for guns in that it requires no gun arm and corresponding attachments. Furthermore, since the distance at which mines are planted will in general be small, the board, without any change in size, may be used with a much larger scale, say, 150 yards or even 100 yards to the inch, and the arms graduated accordingly.

The stations are manned during the planting of mines and the location of distribution boxes, as well as during operations.

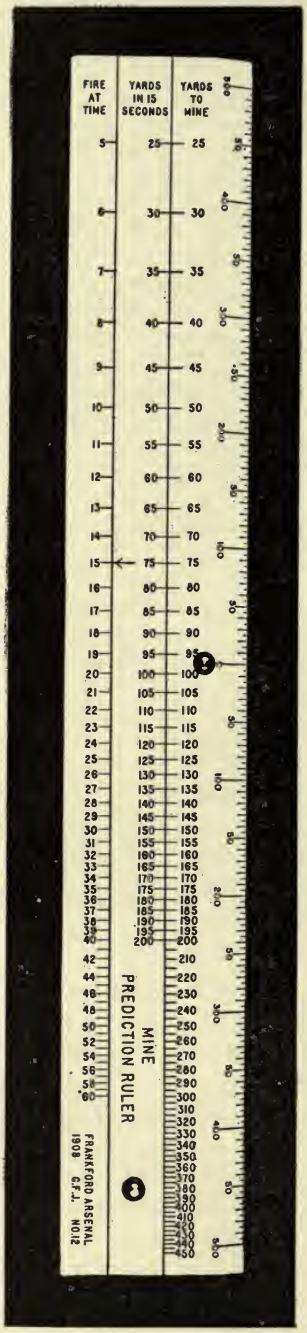


FIG. 15.—PREDICTION RULER.

For planting buoys signals may be made from the primary, from the secondary, or from both, as conditions warrant.

Observations are taken on each mine as planted, the data are recorded, and the position of each mine is plotted.

During operations vessels may be tracked by the vertical or by the horizontal method of position finding. If by the former, either the command "Fire" may be given when the vessel is on the cross wires of the instrument set at the range and azimuth of a mine, or the time from any point to the instant of passing over a mine may be found by means of the prediction ruler (see below) and the command "Fire" be given at the proper instant, as indicated by the stop watch. For the horizontal base system the latter method must be used.

Prediction ruler (fig. 15).—This is a 10-inch white celluloid slide rule with a beveled edge. The slide is graduated in "Yards in 15 seconds," and on the left and right of the runway, respectively, are a "Fire at time" and a "Yards to mine" scales. The beveled edge is graduated from the center outward in both directions with "0" in the center of the scale and "500" at either end. Each 50 and 100 has its value engraved on the scale.

Method of using.—Plot the position of the target for a 15-second interval. With the beveled edge find the distance the target has passed over during the interval; and also determine the distance from the last plotted position to the mine. Move the slide until the graduation corresponding to the "Yards in 15 seconds" is opposite the graduation corresponding to the "Yards to mine," and read the "Fire at time" scale opposite the arrow on the slide. The reading will be the number of seconds from the last plotted position to the mine which the vessel is approaching. A stop watch is started at the time of the last observation on the target, and at the expiration of the time obtained from the "Fire at time" scale the command "Fire" may be given.

Observation firing.—The mine commander's station is connected with the casemate by telephone. At the command "Observation firing" sent to the casemate, the casemate oper-

ator will see *that all automatic switches are up, and that all firing switches are open.* He will then close the double circuit breaker, and switches 4 and 9, which will energize the busses of the power panel. At the command "Group ——, mine ——," the operator will close switches 3 and 8 on the power panel, thereby putting both D. C. and A. C. power on the operating boards. At the command "Ready," given from the mine commander's station at the proper time, the operator will stand ready to trip the corresponding automatic switch. At the command "Fire" the automatic switch will be tripped and the firing switch will be closed. Without delay, after the mine is fired, the firing switch and the power switch will be opened, the automatic switch closed up, and the mine switch opened on the mine block.

If the mine is struck before the command "Fire" is given, the automatic switch will fall, and the mine should be fired by closing the firing switch unless there are positive orders to the contrary.

Contact firing.—For contact firing the mine system will be set so that a signal will be sent to the casemate and the mine will be fired when the latter is struck by a passing vessel. This is the normal method of firing in actual service. At the command "Contact firing," which may be given for all groups, or certain individual ones, the casemate operator will see *that all automatic switches are up, power and mine switches closed, and firing switches open;* he will then close the double circuit breaker, and switches 4, 9, 3, and 8 on the power panel. This puts both D. C. and A. C. on the operating boards. He will then close the firing switches on all the boards or on such as may have been indicated. When a mine has been fired, the corresponding mine block will be cut out.

If it is desired to delay the firing of a mine after being struck, the command "Delayed contact firing" is given. The operations are the same as for contact firing except that the firing switch is closed by the operator a short time after the mine has been struck or when directed to do so. After the mine has been fired the firing switch will be opened, and the corresponding mine block will be cut out.

APPENDIX NO. 1.

EXPLOSIVES.

The latest adopted explosive for submarine mines is trinitrotoluol, also called trotol. The commercial names for this explosive are trinol, trotyl, and triton.

Wet guncotton is used extensively for submarine mines and in emergency other commercial high explosives may be employed, preferably dynamite.

Trotol is a fine crystalline yellow powder, much resembling brown sugar. It is manufactured by nitrating toluol. It is very insensitive to shock or friction, insoluble in water, very stable in storage, and very powerful when detonated. Its melting point is about 81° C., its ignition point is about 197° C., its specific gravity in powdered form is about 1.55; it has no dangerous chemical action on metals.

The priming charge is a fuse can full of crystalline trotol.

Trotol is supplied in wooden boxes doubly lined with wax paper, each box containing about 50 pounds of explosive. The date of receipt at the post and the name of the explosive shall be painted on each box. The boxes should be stored in tiers with the marked end out, the bottom tier resting on skids. The explosive is not dangerous to handle, but the same care should be observed in storing and handling as with other high explosives. It should be stored in a perfectly dry place, preferably in a magazine. If it is impracticable to store in a magazine, the explosive may be stored in the driest place available where it is protected thoroughly from all fire risks. If from any cause the boxes of explosive are wet and there is reasonable assurance that the interior has become wet, a box should be selected and opened. If the interior is wet, a full report of the circumstances shall be made to the War Department. Boxes should be opened and the contents dried in open air out of the direct rays of the sun.

Trotol may be stored with wet guncotton, explosive D, and dynamite.

Inspection at posts will be limited to seeing that the rules for storage and care are strictly observed. Technical inspections will be made, when required, by the Ordnance Department.

Wet guncotton in the form of compressed cakes is supplied in boxes lined with zinc, the lid being screwed down upon a rubber gasket so as to prevent the loss of water by evaporation. Each box contains 100 pounds of dry guncotton. In the lid is a small flush cap which screws down upon a rubber washer and closes a tube communicating with the interior of the box. Upon each box there is painted by the manufacturer the net and total weights. Shipping regulations require that guncotton should be wet with water so that the water is 20 per cent of the weight of guncotton and water. This is too much water for full detonation, and the guncotton upon receipt at a post should be dried out so that the weight of water is from 12 to 15 per cent of that of the dry guncotton. The guncotton is dried by opening the box and pyramiding the guncotton on the lid and in the box so that there will be free circulation of air between the cakes. The use of an electric fan in this connection will ordinarily materially facilitate the operation. By weighing pilot cakes it may be determined when the proper amount of water has evaporated. The guncotton is then repacked, lid screwed down, and the weight chalked upon the end of the box. The guncotton should be placed while drying so that it is not in the sunlight and should be handled with clean cotton or rubber gloves.

In addition to the regular monthly inspection the boxes are reweighed quarterly under the supervision of the officer responsible for submarine-mine explosive, and the gross weight so found chalked upon the end. Should any box show any decided decrease in weight the screw cap in the lid is removed, enough fresh water, preferably distilled or rain water, added to bring it up to its original weight, and the screw cap replaced.

Magazines in which guncotton is stored should not be allowed to attain a temperature as high as 100° F. for any length of time.

Guncotton which is kept wet may deteriorate after long storage, but will not become dangerous.

Wet guncotton can not be ignited by a flame, but gradually smoulders away as the outer portions in contact with the flame become dried.

A brownish or reddish shade is sometimes seen in cakes of guncotton. This is due to the presence of iron in the wash water and does not indicate decomposition.

When storing guncotton in the magazine the piles of boxes should be made so as to give free circulation of air and the greatest convenience in handling consistent with the capacity of the magazine.

In the event of damage to any case, which may cause loss of water by evaporation, the contents shall be removed at once, repacked in a guncotton box which has been washed with soda solution, the proper amount of water added to the contents, and the box closed. The gross weight shall be marked on the case. In repacking avoid as much as possible handling the cakes with the bare hands. This is for the protection of the guncotton from oil or acid of any kind. Clean cotton or rubber gloves are suitable covering for the hands when engaged on this work.

If for any reason the cases are subjected to dampness sufficient to cause unusual deterioration of the cases, they should be removed from the magazine and dried, out of the direct rays of the sun.

Guncotton containing 12 or 15 per cent of moisture may be stored with explosive D, trotol, and dynamite, but never with dry guncotton.

Empty cases, before being placed in storage, must be washed thoroughly to remove all traces of guncotton.

For a charge of wet guncotton, the priming charge is dry guncotton. This may be either of crumbled guncotton or cakes made to fit the fuse can. The compressed primer cakes are supplied wet and bored with holes to receive the fuses and the loading wire.

Should the supply of guncotton primers become exhausted fresh ones may be prepared as follows: Two blocks of soft pine are used, one 3 inches square, the other circular and 2.9 inches in diameter. A cake of wet guncotton is clamped between these blocks. Using a fine joiners' saw and the circular block as a gauge, a cylinder is sawed from the cake. The cylinder is then smoothed down with a rasp. Four of these are prepared for each charge and in each one of them a hole about $\frac{9}{16}$ inch in diameter is bored. While boring the hole the cake must be tightly clamped between two pine blocks to prevent it from splitting; to insure that all the holes will be in alignment it is advisable that the upper wooden block be provided with a $\frac{9}{16}$-inch hole and be thick enough to enable this hole to serve as a guide for the bit. The boring is done with the ordinary bit, which must be sharp, so as to cut clean. *It is not safe to saw or bore a dry guncotton cake.*

It is essential that the guncotton primer be thoroughly dry. The primers may be dried by exposure to the air or by means of drying ovens supplied especially for the purpose. To air-dry a primer, it is placed on edge upon a shelf of wire gauze or netting which is hung up indoors where there is a free circulation of dry warm air. Drying should continue until weighings on two successive days show no appreciable loss. This may require a week or more.

In drying with an oven the cakes are laid on edge on the shelves and the temperature of the oven is kept at about 100° F.; it should not exceed 104° F. The heat is provided by means of a bank of lamps placed under the hood and the current of warm air regulated by the size of the lamp bank and the openings in the top of the oven. Under no circumstances must an open flame be used as a source of heat. The drying in this case also is continued until successive weighings of samples show no appreciable loss.

Whenever it is necessary to dry more than 50 pounds of guncotton primers for immediate use the guncotton should be placed in the drying oven and exposed to the action of an electric fan placed about 4 feet in front of the open door until the moisture content is reduced to about 6 per cent,

when the drying should be completed by the use of the bank of lamps as described in the preceding paragraph.

In each case, to test the dryness of the primers, take a cake and split it in four or five pieces and detonate each separately with a fuse.

It has been determined that about 5 per cent of water is the maximum content for unconfined guncotton capable of detonation by a Du Pont No. 30 fuse.

Priming charges are not to be prepared until just previous to the time they are to be used in loading. When the primers have been dried, they should be kept in well-sealed jars unless they are to be used very soon after drying, in which case they will be stored in assembled fuse cans; when thus stored the assembled fuse cans should be kept in a cool, dry, and secure room away from other explosives. If, however, the primers are to be stored for any length of time, two strips of blue litmus paper are inserted between the cakes, which are inspected from time to time. If the litmus paper shows decided redness, it should be removed and fresh strips inserted. If these strips turn red in a few hours, the primers should be thoroughly wet with fresh water. In general, the period of storage will be short and no particular examination of the dry guncotton will be required.

Dry guncotton should be handled as little as possible, to prevent crumbling and scattering of guncotton dust. Finely divided guncotton is difficult to remove by brushing and if allowed to collect about a room may give serious trouble by flashing should a portion become ignited. This dust may be removed with a damp sponge or cloth.

Dry guncotton which is not used as contemplated shall be rewet with the proper amount of water and repacked.

Samples of each lot of guncotton issued to the service are preserved in the laboratory of the Ordnance Department for chemical test. These retained samples are subjected regularly to technical inspection and test by that department to determine their condition as to stability. This will insure the detection of lots that are deteriorating and their removal from the posts or their destruction before they have deteriorated to such an extent that they become dangerous.

Dynamite.—Dynamite cartridges are packed ordinarily in sawdust in wooden boxes. Each cartridge is wrapped in paraffin paper. The cartridges are arranged in the box so that when they are transported all cartridges will lie on their sides and never on their ends. Usually the amount of explosive in a single package will not exceed 50 pounds.

The boxes must never be allowed to stand so that the cartridges will be vertical.

Like other nitroglycerin, dynamite freezes at about 40° F., and in its frozen condition is, under ordinary circumstances, less liable to explosion from detonation or percussion than when thawed, but more susceptible to explosion by simple ignition. Should any of the nitroglycerin be exuded, the dynamite cartridges are much more sensitive to explosion by a blow.

It is important that dynamite cartridges be kept dry. If exposed to a moist atmosphere, there is a tendency of the water, condensed from the air on all exposed surfaces, to displace the nitroglycerin.

The cases should be raised from the floor on skids and the floor underneath covered with clean sawdust. The sawdust should be removed from time to time, the old sawdust being burned in the open air.

Rubber gloves should be worn in handling this explosive, or in the absence of rubber gloves cover the hands with grease and wear cotton gloves. This is for the protection of the skin from the injurious effect of nitroglycerin.

Dynamite may be stored with wet guncotton, explosive D, and trotol.

Date of receipt at post shall be marked on each box.

The priming charge for dynamite is a pound of loose dynamite contained in a small bag which fits easily into the fuse can. In filling the bag rubber gloves must be worn. To insert the fuses the bag is opened and the fuses embedded in the explosive, the choke being tied around the fuse wires.

At the monthly inspection all boxes shall be examined to see if they are dry. If not dry, all shall be exposed to the dry air out of the direct rays of the sun.

The principal source of danger from dynamite is in the exudation of the nitroglycerin. Exudation is indicated by the presence of small white, oily, lustrous globules of liquid, either among the particles of dynamite or on the packages. If such globules are discovered, they may be identified positively as nitroglycerin by absorbing a drop in a piece of unglazed paper, which should be placed on an anvil or other piece of metal, and striking it a sharp blow with a hammer. If it be nitroglycerin, an explosion will occur. Another test is to set fire to the paper, and if the liquid be nitroglycerin it will burn with a crackling noise and a greenish-yellow flame.

If exuded nitroglycerin has stained floors or other material not readily destroyed, the nitroglycerin may be decomposed and rendered harmless by washing with "sulphur solution." This solution may be made by boiling 50 pounds of lime in a barrel of water and adding powdered sulphur until the solution will take up no more. This will require about 20 pounds of sulphur. The resulting bright orange-colored solution should be filtered and only the filtrate used. A suitable filter for this purpose is a piece of thin cheesecloth. Sodium carbonate may be used in the place of lime.

Dynamite may be destroyed by burning in small quantities at a time. Slit the cartridge with a knife, spread out the contents over some straw or shavings, and ignite carefully. Do not attempt to burn frozen dynamite.

Mine fuses.—These are regular commercial electric fuses, extra quality, and each contains about 25 grains of mercury fulminate. Fuses are supplied in pasteboard boxes containing 50 each, pasteboard boxes being shipped in suitable wooden boxes. They are supplied with long leads which are cut to proper length when the mines are loaded. *They must not be stored with other explosives.*

Loading mines.—In loading mines the following precautions are observed:

(*a*) Funnels are used to cover the screw threads.

(*b*) Trotol is poured through the funnels.

(*c*) Cakes of guncotton or packages of dynamite are passed through the funnels by hand.

(*d*) The screw threads are wiped carefully before the compound plug is inserted.

(*e*) Pieces of canvas or paulins should be spread upon the floor of the loading room. After the loading has been completed the canvas should be removed and thoroughly cleaned. The floor of the loading room should be scrubbed and all refuse destroyed.

Unloading mines.—Mines charged with trotol or wet guncotton may be unloaded without danger; the compound plug being unscrewed, the cakes of wet guncotton are removed by hand, repacked in the original boxes, a little fresh water added, and the boxes closed. If loaded with trotol, the charge is poured out into the boxes, which are then closed. Trotol should be inspected carefully when removed from the case, and if there is indication that any of it has undergone a change while the mine was loaded, a report should be made to the War Department.

In unloading mines charged with dynamite too many precautions can not be taken. The mine should be held either in an opening in a raft or behind an earthen traverse and the compound plug removed by some arrangement which may be operated from a safe distance. If the mine has been planted for some time the recovered dynamite is usually destroyed. Sometimes the interior of the mine case may be found coated with an extremely thin film of exuded nitroglycerin. This film may be destroyed by filling and thoroughly rinsing the case with "sulphur solution."

APPENDIX NO. 2.

THE HORNSBY-AKROYD OIL ENGINE AND GENERATOR.

(See also Artillery Notes, No. 12.)

The engine.—This is a horizontal, single-acting, single-cylinder kerosene engine, having a flyball governor and operating on a four-stroke cycle. This cycle consists in turn of the explosion on the first outstroke, the expulsion of the products of the explosion on the following instroke, the intake into the cylinder of a mixture of air and oil vapor on the following outstroke, and the compression of this explosive mixture on the next instroke. This cycle therefore requires two complete revolutions of the crank shaft for one complete set of operations.

One one side of the cylinder near the closed end is a valve box containing two valves, the air-inlet valve and the exhaust valve. The air inlet and the exhaust valves are actuated by separate levers, each lever being moved by a cam mounted on a horizontal shaft, driven by the crank shaft through worm gearing. This horizontal shaft makes but one revolution while the crank shaft makes two; thus the air inlet and the exhaust valves are each opened once every two revolutions of the flywheel.

At the back of the cylinder, in prolongation of its axis, is a cast-iron box called the vaporizer, which is always open to the cylinder. Before starting the engine this vaporizer must be heated by an external lamp, so that it will vaporize the oil when it is first pumped into it. After the engine has started running, the lamp is no longer required, as the vaporizer is kept at a sufficient heat by the internal explosions.

A small oil pump, worked by the air-valve lever, draws oil from the oil tank under the engine and forces it into the

vaporizer at the proper time. The oil, on its way from the pump to the vaporizer, passes through a valve box attached to the vaporizer; this valve box has two valves in it, a horizontal one, kept closed by a spring which the oil forces open as it goes into the vaporizer; the other, a vertical one, also kept closed by a spring. Should the engine run too fast, the governor opens this latter valve and allows some of the oil to flow back to the oil tank through the waste pipe. This valve can also be opened by turning the little regulating handle, which will stop the supply of oil to the vaporizer and thus stop the engine.

INSTRUCTIONS FOR WORKING.

Frosty weather.—If there is danger of freezing, on shutting down drain the water from the circulating pipes and cylinder jacket, and valve box if water-jacketed; otherwise they may burst or crack.

Caution.—Before starting, see that the cocks which admit water to the water jacket of the vaporizer valve box are open; that the cock on the main water pipe from the bottom of the water tank is open; that the water in the tank is above the upper circulating pipe; that the drain cock is closed; and that the oil tank is filled with kerosene. *Gasoline must not be used with this engine.*

Heating the vaporizer.—Open the relief cock on top of the engine cylinder. Place the lamp on the stand under the vaporizer; fill the lamp with oil by means of the filling pipe till the oil is 1 inch below the pipe; and put a piece of wick into the cups which are formed around the pipes. These wicks, which should consist of a piece of ordinary asbestos packing, will last for several weeks. Place the lid of the vaporizer cover crosswise on the cover to allow the escape of heated gas and air.

A little alcohol or kerosene should be poured into the cup under the coil and lighted. The cups may be filled with kerosene by closing the air-escape valve and working the air pump. The pressure forces oil out through the vapor nozzle and it will run down into the cups. When this is nearly

burned out pump up the reservoir with air by the air pump. Oil will issue from the small nozzle and give a clear flame. When it is desired to stop the lamp, turn the thumbscrew on the reservoir filling nozzle to let the air out. Should the nozzle become choked it should be cleaned with the small needles for that purpose.

The heating of the vaporizer is one of the most important things to be attended to, and care must be taken that it is hot enough at starting. The attendant must see that the lamp is burning properly and that a good clear flame is given off for from 5 to 10 minutes, according to the size of the engine. If, however, the lamp is burning badly, it may take longer to become heated sufficiently. It is important that this should be carefully attended to, for though the engine may start, if the vaporizer is not as hot as it should be the engine will run badly and perhaps soon stop altogether. Failures of engines to run properly can in most cases be traced to this source.

No time should be lost in starting the engine after the vaporizer has been sufficiently heated, as the engine may not run satisfactorily if the vaporizer is allowed to cool after heating it. The lamp should be left burning a few minutes after starting.

Oiling the engine.—Oiling the engine should always be done during the heating-up of the vaporizer.

See that the oil cups on the two main crank-shaft bearings are fitted with proper wicks and filled with oil. Adjust the lubricator on the large end of the connecting-rod and oil the small end which is inside the piston.

Oil also the following: The bearings on the horizontal shaft and the skew gearing, the rollers at the ends of the valve levers and their pins, the pins on which the levers rock, the governor spindles and joints and the bevel wheels which drive the same, and the joints that connect the governor to the vertical valve of the overflow. For such bearings none but the best engine oil should be used.

It is necessary that a suitable oil should be used for lubricating the cylinder, and unless such an oil be used for this

purpose the engine may run badly and perhaps stop altogether. Under no circumstances must a thick cylinder oil be used, and the oil must not be used over again on the piston. Do not use ordinary lubricating oil. A high-grade gas-engine oil especially suited to this engine should be used and the piston should be kept flooded with it.

Starting the engine.—Throw the hand lever to "To start." Turn the small crutch-handle regulator Y to the position "Shut" and work the pump lever up and down until oil is seen to pass the overflow freely. Turn the regulator back to "Open," work the pump lever up and down a few strokes. Vapor should issue with some force from the relief cock on the cylinder. This indicates sufficient heat. Close the relief cock and pump a few strokes. Man the flywheel and start the flywheel backward, using the weight of the body if necessary, bringing the piston up against compression as sharply as possible, and then release the wheel, when an explosion should take place and the engine start forward. As soon as the engine has sufficient speed to carry it past a full compression, throw the lever to "To work." When full speed is obtained, cut down the pump stroke to correspond to the load, open the oil feeders, and go over the engine carefully, seeing that the cylinder oil feed is working.

Oil pump.—When the cylinder is working at its full power the distance between the round flanges on the pump plunger should be such that the hand gauge (supplied with the engine, and to be found in the tool box) will allow the part stamped "1" just to fit in between the flanges; if at any time the positions of these flanges be altered they can be readjusted to this gauge. The other lengths on the hand gauge are useful for adjusting the pump to economize oil. When running on a medium load, use length marked 2; on a light load, use length marked 3. See that the pump packing is not too tight.

Running the engine light.—When the engine is to run light—that is, with no load or with a light load—it is best to alter the stroke of the pump to the amount of oil that will keep the engine running. This amount can be reduced so that the speed of the engine is a few revolutions under the

normal, which will allow the vaporizer to get a small charge each time and keep it from cooling. The cock on the return of the water circulating pipe may be nearly closed to keep the cylinder warmer. These remarks do not apply when the load is intermittent and the engine is running light for a short time only.

Air-inlet and exhaust valves.—See that the air-inlet and the exhaust valves are always working properly and drop onto their seats. They can at any time, if required, be made tight by grinding with a little flour of emery and oil.

To insure a good seat to the valves when the stems are expanded by heat the stems should clear the set screws on the levers at least $\frac{1}{16}$ inch when the air and the exhaust levers are clear of the cams. A greater clearance is undesirable, as it prevents the full opening of the valves.

If at any time the air-inlet or the exhaust valves appear to be opening or closing at the wrong time, take off the nut on the end of the lay shaft which holds the skew wheel on and see that the chisel cuts on the shaft are opposite to one another. The lay shaft is coned where the skew wheel is fixed on and it is held on simply by friction, the nut being tightened against it.

Should it at any time become necessary to take out the crank shaft, always be sure that the skew-wheel gearing is put together so that the tooth marked "0" on the crank-shaft skew-wheel fits in between the two teeth marked "0" on the oil-shaft skew-wheel.

Vaporizer valve box and pipes attached to vaporizer.—In this box there are two valves. The vertical one is regulated by the governor, and when the engine runs faster than its proper speed the governor pushes it down, thus opening it and allowing some oil to return to the oil tank. The horizontal valve in this box is a back-pressure valve. If at any time this valve is not working properly, vapor will be seen coming out of the overflow pipe; in this case the valve should be examined. By screwing off the outside cap the tail of this valve can be seen; if the valve is turned around a few

times it will probably dislodge any dirt that may be under it; if, however, this does not stop the leakage the valve should be taken out for inspection.

If the horizontal valve and sleeves are taken out at any time, great care must be taken in replacing them to use the same thickness of jointing material as before or the distance the valve opens will be altered.

See that the pipe from the pump to the vaporizer valve box is inclined upward all the way from the pump. If this is not so, an air pocket will be formed in which a certain amount of air will be compressed upon each stroke of the pump. This will cause the oil to flow in slowly and not suddenly as it should. If the oil tank be emptied of oil at any time, air will get into the suction and delivery pipes of the pump and it will take some time before the oil going through the pump and pipes will be free of this air; for awhile thereafter, the engine will not work properly, as the air, by being compressed as the pump works, will interfere with oil being pumped in suddenly. It is best, if the oil gets below the filter in the tank, to work the pump by hand for about 10 minutes, holding the relief valve (on the vaporizer box) so as to get air well out of the pipes.

To stop the engine.—Turn the crutch-handle regulator to "Shut." Close the automatic lubricator. If it is desired to stop the engine for a short time only, put the lamp back under the vaporizer to keep it hot.

Setting the oil engine and the generator.—The engine and generator should be so located that the distance from center to center of pulleys should be as nearly correct as possible when the generator is at the middle point of the base rails, so that the proper tension of the belt may be obtained within the limits of adjustment allowed by the rails.

The two pulleys should be accurately in line and the belt not too tight. The generator base should rest on a wooden frame to separate it from the concrete pier. Both engine and generator should be held firmly in position by anchor bolts.

For the generator bearings a quantity of the best dynamo oil is furnished; the commutator should be clean and smooth,

and the brushes should fit the surface. The commutator should be cleaned occasionally with a little paraffin on canvas, and the brushes should be adjusted, so that when running at full load no sparking occurs.

All electrical connections should be firmly made and kept thoroughly clean. A cover should be kept on the generator when not in use. If the machine be damp it should be allowed to dry before running at full load.

NOTE.—A few new installations have been supplied with 5-kw. gasoline electric sets, and future installations will be similarly equipped. Wherever installed, pamphlets on the care and operation of the gasoline sets have been furnished, containing full instructions for the guidance of those concerned.

APPENDIX NO. 3.

THE STORAGE BATTERY.

(See pamphlets issued by the Electric Storage Battery Co., Philadelphia, Pa., on General Instructions for the Operation and Care of the Chloride Accumulator.)

Unpacking material.—Great care should be taken in the unpacking and subsequent handling of the various parts of the battery, as many of them are easily broken or bent out of shape by rough handling.

Open the crates or packing boxes on the side marked " Up " and carefully lift contents out; never slide them out by turning the crate on its side.

Upon opening the crates and boxes, carefully count the contents of each package, and check with the shipping list. A number of small parts will usually be found in each shipment, and care should be taken to examine the packing materials to determine that no parts have been overlooked.

Immediately upon opening the crates the materials should be carefully examined for breakage. Cracked jars, whether of glass or rubber, should not be set up, for if put into use leakage of electrolyte may cause annoyance or trouble.

Location of battery room.—The proper location of the battery is important. It should be in a separate room, which should be well ventilated, dry, and of moderate temperature. Extremes of temperature affect the proper working of a battery. The air should be dry, for if damp there is danger of leakage due to grounds.

The ventilation should be free, not only to insure dryness, but to prevent chance of an explosion, as the gases given off during charge form an explosive mixture if confined. For this reason never bring an exposed flame near the battery when it is gassing.

Direct sunlight should not fall on the cells.

The trays, the benches on which the cells rest, and all metal work (iron and copper) should be painted with asphaltum varnish.

Assembling and placing cells in position.—Place the jars, after they have been cleaned, in position on the stands, which should be provided for the purpose and which should be so situated in the room that each cell will be easily accessible. The jars are set in the trays, which previously should be filled with fine dry sand even with the top, the trays resting on the glass insulators.

Place the elements as they come from the packing cases on a convenient stand or table (the elements are packed positive and negative plates together; the positive has plates of a brownish color, the negative of a light gray—the negative always has one more plate than the positive), cut the strings that bind them together, and carefully pull the positive and negative groups apart, throwing the packing aside. After carefully looking over both groups and removing any dirt or other foreign matter, assemble them, with separators between each positive and negative plate.

When putting into the jars be careful that the direction of the lugs is relatively the same in each case, thus causing a positive lug of one cell always to connect with a negative of the adjoining one, and vice versa. This insures the proper polarity throughout the battery, bringing a positive lug at one free end and a negative at the other.

Before bolting or clamping the lugs together, they should be well scraped at the point of contact to insure good conductivity and low resistance of the circuit; this should be done before the elements are taken apart and directly after unpacking, if the battery is to be set up at once. The connections should be gone over and tightened several times after the lugs are first fastened together to insure good contact.

Connecting up the charging circuit.—Before putting the electrolyte into the cells, the circuits connecting the battery with the charging source must be complete, care being taken to have the positive pole of the charging source connected with the positive end of the battery.

Electrolyte.—The electrolyte is dilute sulphuric acid of a specific gravity of 1.210 or 25° Baumé, as shown on the hydrometer at temperature of 70° F.

The electrolyte should cover the top of the plates by one-half inch to three-fourths inch, and must be cool when poured into the cells. The jars should be numbered with asphaltum varnish and a line made with the same material to indicate the height at which the electrolyte should be kept.

Initial charge.—The charge should be started at the normal rate as soon as the electrolyte is in the cells and continued at the same rate, provided the temperature of the electrolyte is well below 100° F., until there is no further rise or increase in either the voltage or specific gravity over a period of 10 hours, and gas is being given off freely from all the plates. Also, the color of the positive plates should be a dark brown or chocolate and that of the negatives a light neutral gray. The temperature of the electrolyte should be closely watched and, if it approaches 100° F., the charging rate must be reduced or the charge stopped entirely until the temperature stops rising. From 45 to 55 hours at the normal rate will be required to complete the charge; but if the rate is less, the time will be proportionately increased. The specific gravity will fall rapidly after the electrolyte is added to the cells, and may continue to fall for some time after charging begins. It will finally rise as the charge progresses, until it is again up to 1.210 or possibly slightly higher. The voltage for each cell at the end of charge will be between 2.5 and 2.7 volts, and for this reason a fixed or definite volage should not be aimed for. It is of the utmost importance that this charge be complete in every respect.

At the end of the first charge it is well to discharge the battery about one-half and then immediately recharge it. Repeat this treatment two or three times and the battery will be in proper working condition.

After the completion of a charge (initial or with the battery in regular service) and the current off, the voltage will fall immediately to about 2.20 volts per cell, and then to 2 volts when the discharge is started. If the discharge is not begun at once, then the pressure will fall quite rapidly to

about 2.05 volts per cell, and there remain while the battery is on open circuit.

Battery in regular service.—A battery must not be repeatedly overcharged, undercharged, overdischarged or allowed to stand completely discharged. After the initial charge is completed, the battery is ready to be put into regular service.

A cell should be selected as a "pilot cell"; that is, one that is in good condition and representative of the general condition of the battery. The height of the electrolyte in this cell must be kept constant by adding a small quantity of water each day. This cell is to be used particularly in following the charge and indicating when it should be stopped.

When the battery is in regular service, the discharge should not be carried below 1.75 volts per cell at full load. Standing completely discharged will cause permanent injury; therefore the battery should be immediately recharged after a heavy discharge.

In usual service, with the normal rate, it is advisable to stop the discharge at 1.90 volts per cell. If the discharge rate is considerably less than normal, the voltage should not be allowed to fall as low as 1.90 volts per cell, for the reason that with a very low rate of discharge the voltage will not begin to fall off until the limit of capacity is almost reached. The fall in specific gravity of the electrolyte also serves as an indication of the amount taken out and is in direct proportion to the ampere-hour discharge, thereby differing from the drop in voltage, which varies irregularly for different rates and degrees of discharge. For this reason, under ordinary conditions, the fall in specific gravity is to be preferred in determining the amount of discharge.

The actual amount of variation in the specific gravity of the electrolyte between a condition of full charge and a complete discharge is dependent upon the quantity of solution in the containing vessel compared with the bulk of the plates. When cells are equipped with the full number of plates, the range will be about 35 points (0.035 sp. gr.); for instance, if the maximum specific gravity reached on the preceding overcharge is 1.209, the extreme limit beyond which the discharge should not be carried is about 1.174. If the cells have

less than the full number of plates, this range in specific gravity is proportionately reduced, except in the case of the "pilot cell," which should be equipped with a device for displacing the excess electrolyte.

The available capacity is temporarily reduced at low temperatures; with a return to normal temperature the capacity is regained.

The battery should preferably be charged at the normal rate. It is important that it should be sufficiently charged, but the charge should not be repeatedly continued beyond that point. Both from the standpoint of efficiency and life of the plates the best practice is the method which embraces what may be called a regular charge, to be given when the battery is from one-half to two-thirds discharged, and an overcharge to be given weekly if it is necessary to charge daily, or once every two weeks if the regular charge is not given so often.

The regular charge should be continued until the specific gravity of the pilot cells has risen to within five points of the maximum, as shown on the last previous overcharge. For example, if on the previous overcharge the maximum is 1.210, then on the following regular charges the current should be cut off when the specific gravity of the pilot cell reaches 1.205. The pilot-cell method of noting the end of charge should not be used with a battery unless all the cells are approximately in the same condition. With an old battery whose plates are not uniform, readings should be taken on each cell to determine the end of charge.

The overcharge should be prolonged until all the cells gas freely and until no rise in the specific gravity and voltage of the pilot cell is shown for five successive 15-minute readings.

Just before the overcharge the cells should be carefully examined to see that they are free from short circuits. If any short circuits are found they should be removed with a stick or a piece of hard rubber; do not use metal.

As the temperature affects the specific gravity this must be considered and correction made for any change of temperature. The temperature correction is one point (0.001 sp. g.) for 3 degrees change in temperature. For instance, electro-

lyte, which is 1.210 at 70°, will be 1.213 at 61° and 1.207 at 79°.

Inspection.—In order that the battery may continue in the best condition it is essential that specific gravity and voltage readings be taken on all cells in the battery at least once a week; the specific gravity readings on the day before the overcharge and the voltage reading near the end; the voltage readings must always be taken when the current is flowing, open circuit readings being of no value. Also, at the end of each charge it should be noted that all of the cells are gassing moderately and at the end of the overcharge very freely.

Unevenness of cells; cause and remedy.—If any of the cells should read low at either time and do not gas freely with the others at the end of charge, examine them carefully for pieces of scale or foreign matter which may have lodged between the plates. If any are noted, remove them by pushing down into the bottom of the jar with a strip of wood. Never use metal of any kind for this purpose.

If, after the cause of the trouble has been removed, the readings do not come up at the end of the overcharge, then the cell must be cut out of circuit on the discharge, to be cut in again just before beginning the next charge, during which it should come up all right.

Impurities in the electrolyte will cause a cell to work irregularly and the plates to deteriorate. Should it be known that any impurity has gotten into the electrolyte, steps should be taken to remove it at once. The solution should be replaced with new immediately, thoroughly flushing the cell with water before putting in the new electrolyte. The change should be made when the battery is discharged, for the impurities will be in the electrolyte when the battery is discharged. Immediately after the change the cell should be charged. If in doubt as to whether the electrolyte contains impurities, a half-pint sample, taken at the end of discharge, should be submitted for test.

Sediment.—The accumulation of sediment in the bottom of the jars must be watched and not allowed under any circumstances to get up to the plates; if this occurs, rapid deterioration will result. To remove the sediment, the simplest way,

if the cells are small, is to lift the elements out after the battery has been fully charged, draw off the electrolyte, and then dump the sediment, and clean the jar with water, getting the elements back and covered with electrolyte again as quickly as possible, so that there will be no chance of the plates drying out. Electrolyte, not water, will be required to complete the filling of the cells, the specific gravity being adjusted to standard (1.210 at the end of charge).

Evaporation.—Do not allow the surface of the electrolyte to get down to the top of the plates; keep it at its proper level (one-half inch to three-fourths inch above the top of the plates) by the addition of pure water, which should be added at the beginning of a charge, preferably the overcharge. It will not be necessary to add electrolyte except at long intervals or when cleaning, as noted above. Electrolyte added to replace loss should be of specific gravity 1.210.

Battery used but occasionally.—If the battery is to be used at infrequent periods, it should be given a "freshening" charge every two weeks.

Putting the battery out of commission.—If it is thought best to put the battery out of commission for a time, then it must be treated as follows: After thoroughly charging, syphon off the electrolyte (which may be used again) into convenient receptacles, preferably carboys which have been previously cleaned and have never been used for other kinds of acid, and as each cell becomes empty immediately fill it with fresh, pure water. When water is in all the cells allow them to stand 12 to 15 hours, then draw off the water; the battery may then stand without further attention until it is again to be put into service; then proceed as in the case of the initial charge, as described above.

If for any reason any cell becomes discharged before the others, it should be cut out on discharge and worked up to normal before being used.

Should the battery sulphate, charge and discharge frequently, not using less than one-half normal rate at any time and increasing to full rate as the plates show signs of

recuperation; keep the temperature of the cells below 100° F. Frequent exercise will clear the plates in a badly sulphated battery.

Keep careful records of all charging voltages, specific gravities, and troubles with the cells.

The following is a recapitulation of the important points in operating a storage battery:

CONDENSED INSTRUCTIONS.

1. Excessive charging must be avoided. A battery should not be undercharged, overdischarged, or allowed to stand completely discharged.
2. Keep the electrolyte at the proper height above the top of the plates.
3. The daily and weekly readings should be regularly and accurately taken and recorded.
4. Inspect each cell of the battery carefully at regular intervals.
5. If any low cells develop do not delay in bringing them back to condition.
6. Do not allow the sediment to get up to the plates.
7. Do not allow impurities, either solid or liquid, to get into or remain in the cells.
8. Have the battery room well ventilated, especially while charging.
9. Never bring an exposed flame into the battery room during or shortly after the gassing period of a charge.
10. Keep the floor and other parts of the battery room clean and dry.
11. Keep the iron, copper, or other metal work about the battery room free from corrosion.
12. Keep all connections clean and tight.
13. Post a copy of these condensed instructions in a conspicuous place.

APPENDIX NO. 4.

SUBMARINE MINE CABLE.

Submarine mine cable is shipped on reels having an outer sheathing for protection in transit, with at least 12 feet of both ends of the cable brought out and coiled on the head of the reel for test purposes. If the cable is not for immediate use, it should be moved to the cable tank, and by means of the overhead trolley and cable tongs put in its position in the tank, the two ends being properly tagged and firmly fixed so as to allow it to be tested. In arranging the multiple cable in the tanks that which is to be used first should be most readily accessible.

The cable tank should be provided with a cover to keep it clean, as well as to lessen as much as possible variations of temperature. Enough clean water to cover by several inches the outer sheathing of the cable reels should be kept in the tanks, but in climates where the water in the cable tanks would normally freeze to a depth exceeding 2 feet, the water should be let out of the tanks before ice begins to form and not again admitted until the following spring. In localities where the tanks may become a breeding place for mosquitoes, as a preventive measure, salt water from the ocean or bay should, when practicable, be used for filling the tanks, or where it is necessary to use fresh water sufficient salt should be added to produce a 3 per cent solution. No oil or kerosene should be used in the tanks.

The methods of recording tests and of classifying and transferring submarine mine cable are prescribed by orders from the War Department. The tests of submarine mine cable at posts will consist in determining the insulation and conductor resistances.

The insulation surrounding the conductor of a cable is supposed to be uniform in regard to quality of material,

density, and thickness. The resistance which it offers to the passage of a current through it will then vary inversely with its length. In comparison the insulation resistance of 1 mile of cable is taken as the standard. This insulation has a large negative temperature coefficient; that is, an increase of temperature lowers its resistance. It is customary to reduce all insulation resistance to that at a standard temperature of 60° F., and for this purpose reduction factors applicable to the particular insulation compound should be furnished with the cable. (Note: It has been found that for most compounds, if the logarithms of the resistance are plotted as ordinates against the temperature in degrees F. as abscissæ, the resulting curve will be very nearly a straight line.)

The ordinary methods of measuring resistance—that is, by means of a Wheatstone bridge, or by fall of potential, or by voltmeter—can not be used in measuring resistance as high as that of the insulation of a submarine cable. For this the direct deflection method is employed.

In brief, this consists of the following steps:

First. The deflection produced in a galvanometer by a current from a battery through a known resistance, usually 100,000 ohms, is determined, whence is calculated the resistance through which this same battery would produce a deflection of one point using the unity shunt. This is expressed in megohms and is called the galvanometer "constant" under the conditions.

Second. The deflection produced by the current from the same battery through the insulation of the cable is determined, whence, from "First," the corresponding number of megohms is calculated.

Third. This multiplied by the length of the cable in miles and corrected for temperature gives the required insulation resistance per mile.

This testing can be made most satisfactorily on dry days, but a close adherence to the instructions herein given relative to the preparation of the cable ends, the insulation of the cable lead and of the battery, and the drying out of the test room and instruments should enable satisfactory work to be

done under adverse conditions of weather or climate. The following apparatus is required: Reflecting galvanometer, universal shunt, special testing key, 100,000-ohm resistance box, battery of dry cells giving approximately 100 volts, and stop watch.

Figure 16 shows diagrammatically the arrangement of the apparatus for testing a reel of cable. As a rule the instruments should be so placed that one person may manipulate the key and the shunt while at the same time observing the galvanometer.

The 100,000-ohm box, as a protection to the galvanometer in testing, is always kept in the circuit and its value should be subtracted from the resistance determined, except in the case of high insulation resistance when it will not be necessary to make the subtraction.

The universal shunt is always employed with the galvanometer and is used both to vary the current through the latter and to protect it from a violent throw at the instant of making or breaking the circuit at the testing key. This last is accomplished by having the shunt on zero at such times.

The galvanometer being a very sensitive instrument must be solidly supported so as to be free from jars or vibrations.

The special testing key, shown diagrammatically in the figure, has its binding posts plainly marked. It is a double throw key and has two positions upon each side. When completely closed to the right, the cable is charged through the galvanometer from the positive pole; when to the left, from the negative pole of the battery. In each case the deflection of the galvanometer is in the same direction. When partly closed on either side, the cable is discharged to earth through the galvanometer. (Note: It will be observed that the connections are such that the galvanometer is always connected to the cable core and never to the ground. With this connection, *so long as the lead PX is free from leaks or grounds*, the galvanometer measures only the current actually passing through the core and not that leaking through any imperfect insulation in the battery and leads.)

Cable testing is a very simple operation, but extreme care is necessary in all operations.

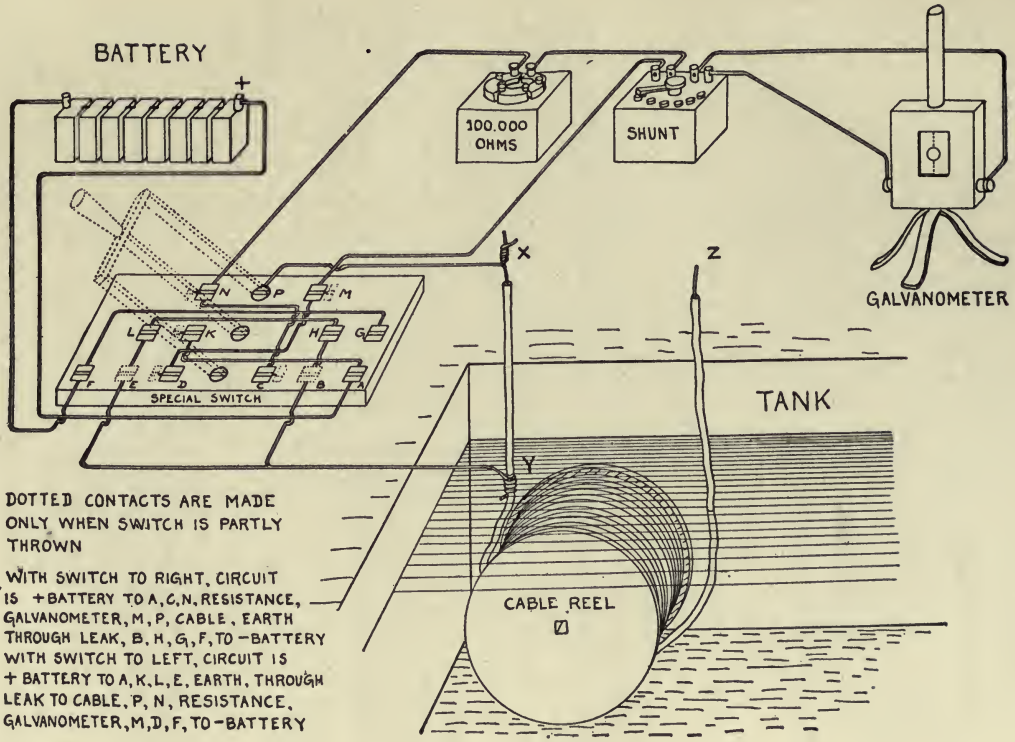


FIG. 16.—CABLE TESTING.

The following is a detailed description:

I. **Preparing the cable for testing.**—1. Closely examine each conductor end. Look particularly for unusually hard or brittle insulation and for torn, pinched, or punctured insulation, especially near the ends of the armor wires. If any of the ends are not in perfect condition, cut off enough cable to secure good ends. (*Caution.*—Do not cut off more than enough to secure good ends, for after three or four tests it may be necessary to unreel the whole cable to secure enough of the inner end above water.)

2. Verify the tagging. Remember that the "shore end" is the end from the outer coils on the reel and is numbered clockwise. The other end is numbered contraclockwise.

3. The "ground" should be made by taking several turns of bare copper wire around the armor of the cable to be tested and soldering them in position. One such ground in each tank is sufficient. Whenever "ground" or "earth" is subsequently spoken of, this ground in the tank is meant, and not a connection to ground at some point outside the tank.

4. The leads PX and BY (fig. 16) should be of loading or other heavily insulated wire. They must be carefully insulated from each other, from the ground, and from the walls or other parts of buildings. This is especially true of the cable lead PX. In damp weather porcelain-knob insulators and porcelain tubes (the latter for use in passing through walls or partitions) may not be sufficient to afford proper insulation for the cable lead. In such case the latter should be suspended *in the air* from the testing switch to the cable tank by means of several chains of paraffined porcelain insulators suspended by marline or protective tape which has been boiled in paraffin. These suspensions should be in each case under cover and should be kept as dry as possible. The length of the leads is immaterial. If loading wire is used, the distance between supports should be short (not over 50 feet), as this wire stretches considerably from its own weight, pulling out the insulation and giving a very thin wall, particularly at points of support. Extreme care should be taken to tighten up on the knob insulators, in case they are used, just enough to hold the wire without pinching the insulation.

5. Using a double connector, join the lead BY to the ground wire on the cable above the surface of the water. Put a connector on the end of the other lead so that it can be readily attached in turn to each conductor.

6. Any protective covering, such as armor, jute, etc., should be removed from the ends of the conductors for a distance of about 12 inches, thus laying the insulation coating bare. This latter should not be handled and must be kept scrupulously clean. With a *clean dry* knife prepare each conductor of the cable to be tested by cutting off about 1 inch of the insulation from each end of the wire and then tapering the end of the insulation for about 1 inch, leaving a perfectly clean surface. In damp weather dip each end of each conductor into melted paraffin (not boiling, but heated above 212° F.). Secure one end of the cable so that it is well separated from the surrounding objects and separate the conductors so that no ends are touching.

7. Take one strand of a loading wire about 4 feet long and wrap it two or three times around the projecting copper end of each conductor at the other end of the cable, then connect it to earth. See that the conductors at this end are dry. Leave the lead PX disconnected and suspended in the air.

II. **Setting up the testing apparatus.**—1. Select a light, dry room as near the cable tank as practicable.

2. Use dry cells for the battery. The voltage of the battery should be such as to give a full scale deflection of the galvanometer through the resistance employed for taking the constant (with shunt at $\frac{1}{100}$). Large galvanometer throws are essential for reliable results.

Set up the cells on shelves in a small closed closet or box, with narrow strips of wood or heavy cardboard laid between each row of cells, lengthwise and crosswise. The height of each strip should be about half the height of a cell, so that the two layers of strips will come nearly to the tops of the cells and keep them well separated. Wire the cells in series and bring the terminals out to a double-pole single-throw switch, which should be on a heavy porcelain or slate base

and rated for at least 250 volts. (It may be found desirable to install some electric lamps in the closet to keep the battery dry.)

If difficulty is experienced in eliminating grounds from the battery set up in this manner, the battery box should be suspended in air by means of chains of paraffined cleats.

3. Set up the galvanometer on a pier or on a window sill if the building is of masonry. It should be insulated by placing its feet on a slate or ebonite slab, or in glass insulators. Remove the cover. Adjust the level until the suspended coil hangs freely. Maneuver the suspended coil, by means of the knob at the top of the tube, until its face is parallel with the face of the instrument. Then adjust the level until the upper suspension hangs in the center of the supporting tube, and the air gap between the coil and armature is symmetrical. Replace the cover. Put on the scale and the telescope. Turn the mirror so that it reflects the 0 of the scale approximately, getting exact adjustment by moving the scale. Be careful (particularly in dry weather) not to touch the glass of the cover or to do anything which will produce a static charge on the glass.

The galvanometer scales are usually graduated in equal divisions corresponding to 1 millimeter on the circumference of a circle whose radius is 1 meter. Each tenth division is usually marked with a number. This number is sometimes 1 instead of 10, 2 instead of 20, and so on. The number of divisions to read and record is the number of smallest (millimeter) divisions. Do not try to read closer than $\frac{1}{2}$ of one division. The larger the throw the less the personal error. No accurate conclusion can be drawn from a very small throw.

4. Place a table or low shelf conveniently to one side and place the shunt, the testing key, the $\frac{1}{10}$ megohm box, and a voltmeter on it. The apparatus should be insulated by an ebonite or slate slab, or glass insulators. Fasten the shunt and the key securely to the table or the shelf. (The use of paraffin paper for insulating instruments is a makeshift at best. It soon gets soiled and creased, then it has to be replaced.)

The use of lamps to keep the apparatus dry may be desirable, or it may be found convenient to expose the apparatus to the sun for a few minutes before beginning the test on any day. The use in the testing room of a small stove or of a gasoline torch for two or three hours before the beginning of the testing will ordinarily prove very advantageous.

5. Wire up as in figure 16, except that the leads from the testing key should be carried to the battery through the double-pole single-throw switch above referred to. (The battery switch should be opened whenever any connections are made or altered.) All leads used in connecting up the instruments should be of heavy copper, and stiff enough to hold permanently any shape to which they are bent. They should be supported at points of connection only, and should not lie on the table or within an inch of each other.

III. **Testing the insulation of the apparatus.**—1. *Voltmeter test of battery insulation.*—This is a rough test, but should be included. A serious ground can be much more quickly located with a voltmeter than with the galvanometer.

(*a*) Disconnect the battery leads at the battery switch; connect + lead of battery to + post of the voltmeter; connect the B end of the lead BY to — post of the voltmeter; — lead of the battery should be in the air. Close the voltmeter switch and read.

(*b*) Disconnect the voltmeter. Connect — lead of the battery to — post of the voltmeter. Connect the B end of the lead BY to + post of the voltmeter; + lead of the battery should be in the air. Close the voltmeter switch and read.

If any deflection is obtained in either case, the battery or its connections are grounded. Locate and remove the ground. (See Foster or some other practical handbook.)

2. *Testing the battery voltage.*—Connect the voltmeter across the battery terminals. Read and record the voltage. (If there is no voltmeter available which will read as high as the battery voltage, take the voltage of the battery in sections and add, or make a multiplier of one of the resistance coils in the $\frac{1}{10}$ megohm box.)

3. *Testing the battery and the apparatus for grounds with the galvanometer.*—With a camel's-hair brush go over all the instruments and carefully remove dust. See that the instruments and connections are dry. Do not blow on the instruments.

Open the battery switch. Connect the battery leads to the battery switch. Disconnect lead PX at P and connect the earth leads BY and EY to the key at "*cable post.*" (Y is grounded.) *Both* battery leads are left connected to the key. The shunt should be on 0. Close the battery switch. Close the testing key to the right. Turn the shunt gradually to the unity post. The galvanometer deflection should be zero. Turn the shunt to 0. Reverse the testing key. Turn the shunt to the unity post. The deflection should be zero. If any deflection is obtained, there is a ground in the battery, the apparatus, or the connections. The test of the cable should not proceed if a deflection is obtained in either position of the key.

In reporting the voltage + to earth and — to earth as "zero" on form, it will be understood that this means zero using the galvanometer, as herein described.

4. *Insulation of leads.*—Turn the shunt to 0. Open the battery switch. Connect the earth leads BY and EY to their proper posts. Connect the cable lead, PX, to "cable" post. See that the cable tank ends of the lead PX is disconnected at X and suspended in the air. Close the battery switch. Close the key and turn the shunt to the unity post. Deflections should be as small as possible and in any case *must be steady and uniform for several trials.* Turn the shunt to 0. Reverse the key, stopping at the discharge position. Turn the shunt to the unity post and wait until the galvanometer rests at 0, indicating that the leads are discharged. Turn the shunt to 0. Close the key all the way down. Turn the shunt to the unity post. The deflection should not differ materially from that noted above. If there is a deflection, the trouble is in the lead PX or its connections. Go over these, carefully examining for dust and moisture and noting particularly the proximity of all wires of opposite potential which cross or lie near each other. If there is a small deflection which can

not be removed, a correction must be applied subsequently to the deflection obtained in the test for the insulation resistance of the conductor.

Using proper care, there are very few days when perfect insulation of the instruments can not be secured. The lead leakage with well-insulated wire put up properly will be noticed rarely.

5. *Use of Price guard-wire.*—As an additional precaution against surface leakage across the insulation at the ends of the conductor it will sometimes be advisable to install an additional lead (not necessarily as carefully insulated as PX) running from the testing switch to the cable under test. This lead should be connected in at the testing switch to the post carrying the lower blade between "D" and "C" (fig. 16); the tank end should be bare of insulation for a sufficient distance to enable the bare wire to be wrapped firmly, without pinching, around the insulation at each end of the particular conductor under test, just below the tapered portion.

The potential difference between the cable core and this guard-wire is thus made practically nil, so that any leakage will be from the guard-wire to the tank, consequently this leakage will not be measured by the galvanometer.

IV. **Take the galvanometer constant as follows:** Open the battery switch.

With a short piece of wire connect the hinge post of the testing key marked "cable" to either "earth" post of the key, the leads to the cable tank being disconnected at E, B, and P. Turn the shunt to 0. Examine the $\frac{1}{10}$ megohm box and see that all the resistance coils are in the circuit. Close the battery switch and the testing key. Turn the shunt to the $\frac{1}{1000}$ post. Watch the swing of the galvanometer and when it has come to rest, read and record. Turn the shunt to 0. The galvanometer should return exactly to 0. If it does not, readjust and repeat until it does. The galvanometer constant is numerically equal to the total throw in *smallest* divisions of the scale multiplied by 100. Remove the connecting wire and replace the leads to the tank.

If at any subsequent time during the test the galvanometer adjustment is disturbed—that is, if it does not return accurately to zero when the shunt is at 0—the constant should be redetermined.

V. **Testing the cable.**—1. See that the testing key is open and the shunt at 0. Connect the earth lead to ground on the cable armor. Remove the earth connection from No. 1 conductor and connect the cable lead to this conductor; in wet weather the connector joint should be dipped in melted paraffin. (In using paraffin to insulate joints or ends bring it just above 212° F. to evaporate any moisture present. It should not be boiling. The paraffin coating should be at least as thick as the rubber insulation and extend back over the rubber for an inch or more.)

2. Close the testing key to the left (+ to earth), stopping at the discharge position, and turn the shunt to the unity post. There should be no deflection. If there is, it is due either to a charge on the cable, which will disappear after a moment, or to earth currents. (It is assumed that the testing apparatus has been thoroughly tested for insulation.) If due to earth currents, the conductor is probably a poor one. Earth currents are readily recognizable by their fluctuating character. Before assuming that the trouble can not be removed, the joint between the lead and the conductor should be examined again. Moisture on the cable end will give a path for earth currents. Note the value and direction of the throw of the galvanometer and record it.

3. Turn the shunt to 0, close the testing key all the way down (+ to earth), noting the time to the second, or starting the stop watch at the same time, if one is available. The time must be accurately noted. The insulation resistance at the end of one minute's electrification is the resistance to be reported.

4. When 35 seconds have elapsed, turn the shunt to the $\frac{1}{1000}$-post and watch the galvanometer throw; if small, move the shunt successively to the $\frac{1}{100}$-post, to the $\frac{1}{10}$-post, and to the unity post. This operation must be completed before 45 seconds have elapsed from the time the key was closed. With

good cable the unity post will always be reached without danger of throwing the galvanometer reading off the scale. Remember that each successive post should give 10 times the throw of the preceding post.

5. At the end of one minute read the deflection, correct for the leakage of the leads and the earth currents, and record. (See example following.)

6. At the end of two minutes read the deflection, correct and record it. For good cable it should be less than the deflection observed at the end of one minute.

7. Turn the shunt to 0, and reverse the key, stopping at the discharge position. Turn the shunt on gradually until the unity post is reached and wait until the reading is 0, indicating that the conductor is discharged. If earth currents are present, 0 will not be reached or will be passed. In this case proceed as before described. A submarine-mine cable conductor a mile long will discharge ordinarily in about three minutes.

8. Turn the shunt to 0, stop and start the stop watch; at the same time close the key all the way down (— to earth).

9. After 35 seconds, start turning the shunt, ceasing at 45 seconds. (See paragraph 4, above.)

10. At the end of one minute read the deflection, correct and record it. For good cable it should be substantially the same as the deflection observed at the end of one minute with + of the battery to earth.

11. Turn the shunt to 0, and reverse the key, stopping at the discharge position.

12. Disconnect No. 2 conductor from ground. Disconnect No. 1 from the lead and connect up No. 2. Connect No. 1 to ground. It is not necessary to wait for No. 1 to be discharged completely before disconnecting it.

13. Proceed with No. 2 as with No. 1 and repeat with each conductor.

14. On the completion of the test all conductor ends should be carefully taped.

15. To determine the correct value of the insulation resistance it is essential that the negative pole of the battery be

connected to the core of the cable, otherwise the products of electrolysis will tend to seal up any fault which may exist and will cause the conductor to appear better than it really is. With the negative pole of the battery to the core the tendency is to deposit copper on the core and thus to lay bare any fault. The insulation resistance of any conductor is therefore found by multiplying the corrected deflection at the end of one minute, with + of battery to earth, by the denominator of the shunt used, and then dividing the galvanometer constant by this product. The resistance of the $\frac{1}{10}$-megohm box is neglected unless the insulation resistance determined is very low, say, under 1 megohm, when the 100,000 ohms should be subtracted from the above quotient.

16. To determine the insulation resistance per mile at 60° F., multiply the actual insulation resistance found by the length of the cable in miles, and this result by the multiplier furnished by the torpedo depot for the particular make of cable, corresponding to the temperature of the water in the tank observed during test.

Example.—Leakage of the leads found to be one-half division. Earth currents found to give $1\frac{1}{2}$ divisions in a negative direction from 0 of the scale. Galvanometer throw at the end of one minute (+ to earth), 15 divisions. The corrected deflection is, $15-\frac{1}{2}+1\frac{1}{2}=16$ divisions.

The galvanometer constant (450 divisions through $\frac{1}{10}$ megohm, shunt at $\frac{1}{10000}$), 45,000 megohms. That is, the battery will give $\frac{1}{10}$ of 450 divisions=45 through 1 megohm, the shunt at $\frac{1}{10000}$; or, what is the same thing, one division through 45 megohms, the shunt at $\frac{1}{10000}$; therefore with the shunt at unity the battery will give one division through $45\times1{,}000=45{,}000$ megohms. The insulation resistance= $45{,}000\div16=2{,}813$ megohms. If the cable is three-fourths mile long, the insulation resistance in megohms per mile is $2{,}813\times\frac{3}{4}=2{,}110$ megohms.

Manufacturer, Safety Insulated Wire & Cable Co.

Temperature of water in tank, 80° F.

Multiplier, 1.7056; 2,110×1.7056=3,599 megohms insulation resistance per mile at 60° F. This result is recorded on the form.

VI. **Copper resistance.**—1. The drop of potential method is quicker than the bridge method under the usual conditions and should be used if the apparatus is available.

Apparatus required.—(*a*) Source of power (110 volts D. C. lighting circuit, casemate battery or generator); (*b*) a double-pole single-throw switch to which the power leads are attached; (*c*) a bank of ten 110-volt lamps in parallel; (*d*) a D. C. ammeter of not more than 0–25 scale; (*e*) a D. C. voltmeter, 0–150 scale.

Place the lamp bank and the ammeter in one side of the power line from the switch to the conductor, and the other end of the conductor to the other side of the power line. Connect the voltmeter across the ends of the cable so as to measure the drop of potential between the ends of the conductor being tested. Close the switch, take simultaneous readings on the voltmeter and the ammeter and calculate the resistance. With the apparatus described a conductor 1 mile long will receive about 2½ amperes and show a drop of about 50 volts. The lamps are inserted as a safety precaution. In no case should the current through the conductor exceed 6 amperes. If the cable has been tested for insulation resistance and all the conductors show high insulation, the lamps are not necessary, provided the cable is at least a mile long.

2. The copper resistance found is reduced to that at 60° F. by multiplying by the coefficient found in the following table with the temperature of the water in the tank at the time of the test as an argument:

Reduction of copper resistance to 60° F.

Temperature.	∂	Temperature.	∂	Temperature.	∂
°F.		°F.		°F.	
10	1.1252	40	1.0468	70	.9781
11	1.1224	41	1.0443	71	.9759
12	1.1196	42	1.0419	72	.9738
13	1.1168	43	1.0395	73	.9717
14	1.1141	44	1.0371	74	.9695
15	1.1113	45	1.0347	75	.9674
16	1.1086	46	1.0323	76	.9653
17	1.1059	47	1.0300	77	.9632
18	1.1032	48	1.0276	78	.9611
19	1.1005	49	1.0252	79	.9591
20	1.0978	50	1.0229	80	.9570
21	1.0952	51	1.0206	81	.9549
22	1.0925	52	1.0182	82	.9529
23	1.0899	53	1.0159	83	.9508
24	1.0873	54	1.0136	84	.9488
25	1.0846	55	1.0113	85	.9468
26	1.0820	56	1.0090	86	.9448
27	1.0794	57	1.0068	87	.9428
28	1.0769	58	1.0045	88	.9408
29	1.0743	59	1.0023	89	.9388
30	1.0717	60	1.0000	90	.9368
31	1.0692	61	.9978	91	.9348
32	1.0667	62	.9956	92	.9328
33	1.0641	63	.9933	93	.9308
34	1.0616	64	.9911	94	.9288
35	1.0591	65	.9889	95	.9269
36	1.0566	66	.9867	96	.9250
37	1.0542	67	.9846	97	.9231
38	1.0517	68	.9824	98	.9211
39	1.0492	69	.9802	99	.9192

The true length of a cable should be that of its center conductor.

From the size of the conductor and its copper resistance the length of the cable may be computed by use of the following wire table:

Table of resistances of pure copper wire at 60° F.

Size B. & S.	Dia. in mils.	Ohms per 1,000 feet.	Size B. & S.	Dia. in mils.	Ohms per 1,000 feet.
1	289	0.11999	16	51	3.8880
2	258	.15130	17	45	4.9030
3	229	.19080	18	40	6.1827
4	204	.24058	19	36	7.8024
5	182	.30338	20	32	9.8316
6	162	.38256	21	28.5	12.397
7	144	.48245	22	25.3	15.625
8	128	.60831	23	22.6	19.712
9	114	.76696	24	20.1	24.857
10	102	.96740	25	17.9	31.343
11	91	1.21960	26	15.9	39.535
12	81	1.5379	27	14.2	49.839
13	72	1.9393	28	12.6	62.848
14	64	2.4453	29	11.3	79.250
15	57	3.0134	30	10.0	99.932

The objections to the use of a bridge for measuring copper resistance are the difficulty of eliminating the resistance of the plug contacts and the time required to secure balance. The resistance of the plug contacts may often be as high as 20 ohms, particularly if used at the tank.

If the bridge is used at all, it should be placed in the testing room, and the same leads employed for testing insulation should be used. The resistance of these leads should first be determined by connecting them together and measuring; this resistance is subtracted from each resistance measured.

VII. **General.**—The key to success in cable testing is great care in every detail. The cable now being furnished is all tested with galvanometers having constants from 200,000 to 250,000 megohms. It has all been accepted after most careful test. The chances are that it is good when it arrives at the post, unless it has been mechanically injured in transit, which should be ascertained by careful inspection when delivered at the post.

Do not accept a single measurement if it shows low resistance, but repeat until certain of results. The time between trials on the same conductor should be as great as practicable. For example: Measurements showing low resistance made in the morning should be repeated in the afternoon; those made in the afternoon should be repeated the next day; the conductor being connected to earth during the interval between tests.

APPENDIX NO. 5.

CARE AND PRESERVATION OF SUBMARINE MINE MATÉRIEL.

Frequent inspections of all articles of submarine mine equipment should be made, not only to check up the property, but also to determine the condition of all matériel, and especially to see if it has been affected by dampness. These inspections should be thorough and detailed, as only in this manner can there be impressed on those directly charged with the care of the property the importance of ventilation, dryness, and the proper use of preservatives.

The generating set, storage battery, motor-generators, casemate transformers, power panel, and operating boards will be installed in the mining casemate, and such tools, appliances, and materials as may be used when this apparatus is in commission will also be kept there.

The explosive will be kept in the magazines and tested and cared for in the manner prescribed in Appendix No. 1.

The multiple and single conductor cable will be kept in the cable tanks as described in Appendix No. 4.

All other articles of equipment will ordinarily be kept in the storehouse, and a noncommissioned officer will be placed directly in charge. It shall be his duty to keep the matériel in the best possible condition, using such details from the submarine mine detachment from time to time as may be necessary to assist him in this work. He shall check up all articles taken from the storehouse during practice and report at the end of the day's work any shortage in tools or appliances that he may discover.

Paints and oils should be kept separate from other stores, and the floor where kept should be covered with 2 or 3 inches

of sand, to be renewed occasionally. Sawdust should never be used for this purpose. Cotton waste which has become unfit for use should be promptly burned. Fuses must not be stored with other explosives.

Gasoline in considerable quantites should be stored in tanks underground and never inside of buildings. Small quantities should be kept outside of buildings in some safe place.

When oil engines or generators are out of commission, their bright parts should be covered with light slushing oil. Brass screw threads and parts of tools that are liable to rust should be covered also. In all cases the light slushing oil should be applied in a thin coat, since this is all that is necessary to give good protection. Before applying the light slushing oil to any surface it should be thoroughly cleaned, so as to be free from rust, water, kerosense, and lubricating oil, as their presence will cause rusting underneath the slushing oil. The protected surfaces should be occasionally inspected and the coating of slushing oil renewed as often as required.

Screw threads of mine cases, steel screw threads of compound plugs, bolts, nuts and washers, and surfaces of flat joints should be kept coated with the light slushing oil or a mixture of machine oil and graphite.

No oils or grease should ever be placed on points where metallic contact of electrical instruments is necessary, nor on india rubber, ebonite, or slate.

Mine cases should rest on racks or skids, and where space permits should not be in contact with each other. In handling mine cases care must be taken not to damage the bails and bolts. They should be arranged so that the holes in the mine cases can be seen easily; these holes should be fitted with a wooden plug which has been thoroughly greased all over its surface. New mine cases, if galvanized, usually will not need painting until they have been in the water. When taken from the water they should be thoroughly dried, and if they should show signs of rust they should be gone over thoroughly with steel wire brushes until the rust is removed. Parts which can not be reached with the brush should be cleaned with three-cornered steel scrapers. A heavy coat of

red lead should then be applied. Seven gallons of this paint can be made by mixing 100 pounds of red lead ground in oil with 5 gallons of raw linseed oil. This mixture should be applied within two or three weeks after mixing. One gallon of paint should give 10 mine cases one coat. After this coat has been allowed to dry there should be applied a coat of white lead toned down to a neutral gray. Seven gallons of this paint can be made by mixing 100 pounds white lead, 2½ gallons raw linseed oil, 2½ gallons turpentine, 1 gallon liquid drier, and adding about 1 pound of lampblack to tone down the mixture.

Mines treated in this way, if kept in a dry storehouse, and not put in the water, should not require repainting for several years. Frequent inspection should be made, however, for in handling the cases and changing their positions on the racks, it will often happen that an abrasion will be made in the surface of the paint, which if neglected may serve as the starting point of a progressive corrosion, which may extend rapidly under the surface of the paint. Should loose paint or rust be seen the case should be repainted. A small wooden mallet may be used to tap the case at all points to loosen scales of rust or paint; then the surface should be thoroughly wire brushed or scraped and the cases repainted as stated above. The inside of mine cases must be inspected to see that the interior surfaces are kept free from rust.

Ground mines and ground-mine buoys should be treated in the manner just described for buoyant-mine cases.

If the oil engine has not been painted, it should be given a priming coat of red lead mixed in oil. This should be rubbed down with pumice stone and two coats of steel-colored paint applied. The second coat should be rubbed down and two coats of varnish then applied. After this the engine should not need repainting for a couple of years. When, however, repainting is necessary, the engine should be rubbed down until all the varnish is removed and a coat of steel-colored paint applied. This coat should be rubbed until no brush marks remain, and one or two coats of varnish should then be applied. The steel-colored paint should be applied flat; that is, the color which is ground in japan

should be mixed with turpentine. One gallon of this paint is more than sufficient to give an engine two coats.

The motor-generators and the casemate transformers usually will not need the priming coat of red lead, as they come from the factory painted. When it is necessary to paint them, one coat of the steel-colored paint and one of varnish will usually be found sufficient.

Anchors, distribution boxes, junction boxes, mooring sockets, shackles, sister hooks, and the ironwork of operating boards and power panels should be painted with asphaltum varnish.

Paint brushes when new, and before use, should be wrapped or bridled with strong twine and soaked in water to swell. After use they should be cleaned with turpentine and put away in water to keep them from drying and becoming unpliable.

Large ropes should be stored on skids, allowing a free circulation of air. Small ropes should be hung on wooden pins. Ropes should be uncoiled semiannually in dry seasons and stretched out for several days to dry. Wire rope must be stored in a dry place where it will not rust. Marline-covered wire rope should be stored where there is a fair circulation of air. The date of receipt should be stenciled on each reel. If not used at the end of five years it should be run through a bath of pure distilled tar oil. This may be done by setting up an empty reel 20 feet in front of the full reel and placing a tub of the tar oil midway between them. As the rope comes off the full reel it is passed through the oil and the surplus oil slicked off with a piece of burlap, thus returning the oil to the bath. The freshly oiled reel will continue to drip for several days, and sand should be put on the floor under the reel to take up the excess oil. After use in water the marline-covered rope should be thoroughly dried out and then reoiled as above described.

APPENDIX NO. 6.

INSTRUCTIONS FOR MASTERS OF MINE PLANTERS.

The matter contained in this appendix is primarily for the information of the masters of those vessels which are called into service for mine-planting purposes upon the outbreak or threatening of hostilities.

The master shall request to be supplied with a copy of Regulations for Mine Planters, U. S. Army.

To each vessel will be assigned a coast artillery officer, who shall be the commanding officer of the vessel. All orders for the vessel shall be given to and through him. He shall have general charge of its business and be responsible for the proper care and disposition of all stores aboard, leaving to the master of the vessel the full and unquestioned control and authority over all matters for which he is professionally responsible.

Any orders to be given by the commanding officer concerning the vessel or its crew will be given to or through the master, except that when planting mines or operating any of the mining appliances or machinery aboard the vessel, the commanding officer, or an officer designated by him, may give instructions directly to any of the vessel's officers or to members of the vessel's crew who have duties directly connected with the mining work.

The duties and responsibilities of the master of a vessel engaged in submarine mine work do not differ materially from those devolving upon him when his vessel is otherwise employed. With respect to every duty the vessel may be called upon to perform, it may be stated that explicit directions as to where the vessel is to go and just what maneuvers it is to execute in the mine field will be given by the officer

aboard, and it is then incumbent upon the master to execute the maneuver according to his best judgment.

The duties that vessels employed as mine planters are likely to be called upon to perform are as follows:

1. To lay out the mine fields.
2. To lay the multiple cable.
3. To plant mines.
4. To take up mines (including replacing defective mines by good ones where necessary).
5. To take up the cable.

The commanding officer of the vessel is responsible for the proper equipment of the vessel with the necessary apparatus for mine planting, for the loading of all the matériel prior to the planting, and for the method of procedure under the above heads.

The master of the vessel will carry out the orders of the commanding officer and is concerned only in the handling of his boat to prevent accidents to it and to the boats engaged in the planting.

The following precautions will be observed by masters:

1. If current flows across the mine field the planting vessel, to avoid accidents, should always pass on the *downstream* side of the yawl boat holding the measuring line.

2. The greatest care should be taken that the measuring line and buoy ropes are not caught in the propellers. If the vessel has twin screws, the upstream propeller should be stopped as soon as the measuring line has been passed to the marking boat. In all cases a man with a boat hook should be posted near the anchor davits and another amidships, to hold the measuring line above the water and clear of the sides of the vessel. Keg buoys, and as much of the buoy rope as possible, should be held on the rail near the stern, letting the rope pay out slowly and under tension, until the propellers are past the rope, then the keg and the remainder of the rope may be thrown overboard.

3. A general rule is never to back either propeller when buoy ropes, measuring lines, or cables are being handled overboard at or near the stern of the vessel.

4. If it becomes absolutely necessary to reverse the propellers when paying out cable, men paying it out must haul it in taut and keep it above the wheel and clear of it. The planting vessel should not pass nearer than 25 feet to the distribution-box boat when cable is leading out from the latter, nor should it pass over any cable, if it can be avoided, if the depth is less than 16 feet.

5. The vessel should proceed after passing the distribution-box boat on such a course that cable will pay off smoothly without becoming entangled. If a cable becomes fouled and entangled, the end should be "let go" at once at the distribution-box boat—the planter should proceed on, not stop nor back its propellers. Mine cable should never be made fast in the distribution-box boat until after a mine is dropped. It is much better to drop the mine out of position than to endanger the propellers of the vessel. The propeller nearest the distribution box should be stopped the moment the bow of the vessel passes the distribution-box boat on its course to drop a mine.

6. If, in planting, the vessel moves *against* the direction of the current, there is little danger of overturning the distribution-box boat if ordinary caution is observed. Should it be necessary to plant against a cross current or with it, it is best to pass the cable end to the distribution-box boat by a launch or small boat. In this way the planter need not pass within 50 or 75 yards of the boat.

7. To avoid getting foul of the buoy rope or mine after the mine is dropped, the helm should be put over so as to throw the stern away from the mine. The vessel should be under good headway so that the propellers may be stopped until they are well past the buoy and buoy ropes of the mine. These points are important; failure to observe them will result disastrously.

In laying multiple cable, the course of the vessel invariably should be against the current. Rather than lay cable with the current it is advisable to postpone laying the cable until a change of the tide causes a favorable direction of current. In the end, time will be saved by waiting. Cable should pay

off on the *upstream* side of the vessel if any cross current is running. All care should be taken that the cable does not get caught in the vessel's propellers. This is of the greatest importance.

As the cable pays out over a chock near the bow of the vessel a man should stand by with a 3-inch strap in readiness to stop the cable should it be necessary, and two men should manipulate brakes to prevent the cable from paying out too rapidly. This is especially necessary if the water is deeper than 50 feet.

Especial care is necessary in planting mines to avoid: (*a*) Colliding with yawl or distribution-box boat; (*b*) picking up cable in the propeller; (*c*) getting the mine cable tangled; (*d*) drifting over the mine after it is dropped.

APPENDIX NO. 7.

MANUAL FOR SMALL BOATS.

The left-hand side of a boat or ship, looking toward the bow, is the *port* side, and the other is the *starboard* side. The men who row on the port side are called the *port oars* and those rowing on the starboard side are called the *starboard oars.*

Boats are called single or double banked, according as they have one or two oarsmen to a thwart.

Thwarts are the seats on which the crew sits; the space abaft the after thwart is called the *stern sheet.*

Floorings and *gratings* are the bottom boards of a boat. They prevent the weight from bearing directly upon the planking.

The *gunwale* of a boat is the upper rail.

The *yoke* is an athwartship piece of wood or metal fitting over the rudderhead.

Yoke lanyards are the small lines made fast to the ends of the yoke, by which the rudder is turned and the boat steered.

The *stem* is the upturned portion of the keel at the bow of the boat, to which the forward ends of the planks are secured.

Oars are said to be double-banked when two men pull one oar.

The blade of an oar is the broad flattened part. The handle is the small part of an oar on the inboard end of the loom, which the oarsman grasps when pulling. The loom is the portion of an oar extending from the blade to the handle. The leather is the portion of an oar which rests in the rowlock. This is sometimes covered with canvas, but is usually covered with leather; hence the name.

Feathering is the term applied to the operation of turning the blades nearly flat to the water after the stroke, with the upper edge turned forward, especially valuable in rowing against a head wind.

Rowlocks are forked pieces of metal in which the leather of the oars rests while pulling. Swivel rowlocks are movable, a pin on the rowlock fitting into a socket in the gunwale.

Thole pins are pins set vertically in the gunwale and are used in place of rowlocks.

The *steering rowlock* is a peculiar form of swivel rowlock (fitted near the stern of a boat) in which the steering oar is shipped. This is sometimes called a crutch.

The *painter* is a rope secured in the bow for towing or for securing the boat.

Boat-falls are tackles made with two blocks and a length of rope; used for hoisting boats.

The *plug* is the wooden stopper fitted into a hole in the bottom of a boat to let water in or out.

A *boat breaker* is a small keg used for carrying fresh water.

A *boat-recall* is an understood signal made to order a boat's return.

BOAT ORDERS.

Oars and rowlocks having been placed in the boat, blades of oars toward the bow, rudder and yoke, if any, stepped and the yoke lanyards clear, the men board and take their proper seats. The man pulling the bow-oar is No. 1, the next man is No. 2, and so on, to the man pulling the stern-oar, who is called the "stroke-oar." The men being seated, with oars handy, the bow-man, who may be No. 1 or an extra man, as convenient, holds onto the wharf, side, or piling, as the case may be, with his boat hook.

Shove off.—At this command the bow-man shoves the boat clear, giving her headway if possible. He boats his boat hook and takes his seat.

Up oars.—The crew simultaneously seize and raise their oars smartly to the vertical (guiding on the stroke-oar) and hold them directly in front of them, the blades fore-and-aft, inboard hands grasping the handles, holding the same well down between the knees, outboard hands grasping the looms at the height of the chin.

Let fall.—The oars are eased down into the rowlocks together, brought level with the gunwale, blades horizontal and

all trimmed on the after oars. Oars must not be allowed to splash.

(1) *Give way together*, (2) *GIVE WAY.*

At the first command the men reach well forward, blades nearly vertical, ready for the stroke. At the second command they dip their oars at the same time as the stroke oar and commence rowing, keeping stroke exactly and all lifting their blades to the height of the gunwale on the return. (Or higher if waves render this necessary.)

TO MAKE A LANDING.

In running alongside a vessel or up to a float-stage or wharf, when several lengths away from same, give the command (while the oars are in the water), *IN BOWS.* The bow oarsman (if there be no extra man in the bow) finishes his stroke, then "tosses" and "boats" his oar, blade to the bow, and stands ready with the boat hook to fend off and hold the landing. When there is sufficient headway to carry the boat properly to the landing, give the command, *WAY ENOUGH.* This order is given while the oars are in the water; the men finish the stroke, then toss and boat their oars with as little noise as possible. The oars are next the rail, the after-oars outboard of the bow oars. If the stroke oarsman is provided with a boat hook, he grasps it and stands ready to help the bow man.

If it be desired to stop rowing temporarily, give the preparatory command, (1) *Stand by to lay on oars*, at which the crew pays strict attention. Then, when ready, give (2) *OARS.* At this command, given while the oars are in the water, the crew finishes the stroke and brings the oars level with the gunwale, blades horizontal, trimmed on the after oars. This position is also used for salutes, as noted hereafter.

If about to pass so close to another boat that a collision of oars seems probable, command (1) *Trail*, (2) *OARS.* At the second command, given while the oars are in the water, the men finish the stroke, and then, while the oars are still in the water, by lifting the handles with their outboard hands.

the looms are thrown out of the rowlocks. The men carry their hands outboard till the backs of their wrists rest on the rails and the oars trail astern. (This movement is used in shooting bridges, where lack of head room precludes *tossing*.)

To bring the oars inboard, command: *OARS.*

At this command the men raise the handles, lower the looms into the rowlocks, and then raise the blades out of the water and swing the oars to the regular position of *Let fall.*

In order to turn the boat short around (being stationary or nearly so) command: (1) *Give way, starboard; back port,* (2) *GIVE WAY;* or (1) *Give way, port; back, starboard,* (2) *GIVE WAY.* The crew keeps stroke just as regularly as in pulling straight away. As soon as the boat points in the desired direction command: (1) *Give way together,* (2) *GIVE WAY.*

If it be desired to check the boat's headway, command: *HOLD WATER.* At this command the men drop their blades vertically into the water, tops of blades inclined slightly forward, inboard hands grasping the handles, outboard arms over the looms to steady the oars against the chest. To prepare the crew for rowing command *OARS,* at which they resume the position described under the heading *Let fall.*

To move the boat astern command *STERN ALL.*

At this command the men back water, keeping stroke as regularly as in ordinary rowing. To resume the position of attention give the command *OARS,* as before.

To toss oars command: (1) *Stand by to toss,* (2) *TOSS.*

The command of execution is given while the oars are in the water, the stroke is completed and the oars raised smartly to the vertical, with blades in fore and aft plane, handles of oars on bottom boards, the wrists of the inboard hands resting on the thighs, outboard hands grasping the looms at the height of the chin, crew sitting upright. To place the oars in the boat give the command *BOAT YOUR OARS.* At this command the oars are lowered toward the bow (not swung outboard) and laid in the boat as before described. This command may be given from the position of *Let fall,* in which case the men toss their oars and proceed as above.

NOTES.

In rowing the blade of the oar should be raised as high as the gunwale after leaving the water and feathered by dropping the wrist. A barely perceptible pause should be made, and the oar next thrown well forward and dropped edgewise into the water, taking care to avoid splashing and chopping. Now swing the oar smartly through the water without giving it any final jerk, and repeat as above. With green crews it may be found necessary for the coxswain to call *stroke*, *stroke*, in order to get the men to pull exactly together.

There should be a mark on the loom of the oar (about the height of the eyes when the oar is at *toss*) to show when the blade is fore-and-aft, thus avoiding the necessity of the men gazing up for the purpose of finding out when this is the case. Never allow a boat's crew to splash with the blades when executing *Let fall.* When resting on oars, insist that they be kept level with the gunwale and at right angles to the keel. Talking among the crew and turning the heads to look at any object should never be allowed while the boat is under way. In most cases, boats should be permanently equipped with a small breaker of fresh water, a spare oar and oarlock and a suitable anchor or grapnel. The anchor rope to withstand a storm should be six (6) times as long as the greatest depth liable to be used as an anchorage. For any small boat in our service a 20-pound anchor and 12-thread (about 1 inch) manila hawser should easily weather a hurricane. A boat should never go out at night without a good, well-filled lantern. Many a boat has been run down through its inability to make its presence known. Before leaving the shore in foggy weather, provide the boat with some sort of a foghorn and a compass, and calculate as nearly as possible the bearings of the landing you wish to make. Take the opposite of this upon returning, making due allowance for tide and wind in both cases. To ride out a gale of wind in an open boat, lash the oars and grating together, making them into a bulky bundle and weight them if possible; span them with the painter and pitch them overboard. This will keep the boat's head to the sea and prevent her from drifting fast. Assist the boat to take the seas head-on by means of a steering oar.

In rowing through a chop, where the rudder is apt to be pitched clear of the water, it should be unshipped and a steering oar used instead. Remember, in making a landing, that the heavier the boat is laden the longer she will keep her way. If you are being towed by a steamer, make her give you a line, instead of using your own, and belay it so it can be cast off in a hurry. Carefully avoid weighing down the bow; always use a short towline when the boat is empty and a long towline when the boat is laden. If the boat's painter is used for a towline, have a knife ready for cutting it if it becomes necessary. Never go close under a steamer's stern unless it is absolutely unavoidable.

Officers in boarding a ship, use the starboard gangway, although they may use the port gangway. Enlisted men use the port gangway or the booms, unless otherwise ordered.

Boat salutes.—The following salutes should be exchanged between boats meeting or passing each other. No junior should pass ahead of a senior without permission.

The junior should always salute first, and the senior should return the salute by touching his cap.

Salutes should be exchanged whenever boats pass near enough to each other for the senior officer to be recognized, whether he be in uniform or not.

Officers without a flag or pennant flying should be saluted with the hand only; those with a flag or pennant flying should, in addition, be saluted by laying on oars.

When a noncommissioned officer is in a boat and meets another boat containing an officer he stands and salutes. If the boat flies a flag or pennant, the noncommissioned officer, in addition, lays on oars.

Officers of the Navy and Marine Corps and foreign officers in boats should always be saluted when recognized.

In laden boats, towing boats, or boats under sail the hand salute only is made on all occasions.

Coxswains in charge of boats shall always rise and salute when officers enter or leave their boats.

Boat keepers shall stand up and salute officers passing in boats and remain standing until the boat has come alongside or passed.

APPENDIX NO. 8.

SUPPLY LIST.

APPARATUS.

Ammeters, portable, 0–25 scale, 1 to each post.
Anchors, buoy, 500 pounds, 5 to each group of 19 mines.
Anchors, mine, 1 to each buoyant mine.
Axle, cable-reel, 1 to each cable-reel frame.
Balances and weights, 1 set to each post.
Battery, storage, 1 to each casemate.
Boards, operating, 1 to each group of 19 mines.
Boxes, distribution, 1 to each group of 19 mines.
Boxes, distribution, 1 to each group of 7 mines.
Boxes, junction, large, 3 to each mile of multiple cable.
Boxes, junction, small, 1 to each mile of single-conductor cable.
Buoy, distribution-box, 1 to each distribution box.
Buoy, marking, 5 to each group of 19 mines.
Buoy, mine, 1 to each buoyant mine.
Cable, submarine, 19-conductor, according to project.
Cable, submarine, 7-conductor, according to project.
Cable, submarine, 1 conductor, according to project.
Cases, gun cotton, as required.
Circuit closer, 1 to each mine transformer.
Clips, cable, 2 for each mine.
Engine, internal combustion, 1 to each casemate.
Frame, cable-reel, 3 to each post.
Fuse can, 1 to each compound plug.
Generator, casemate, 1 to each casemate.
Mine cases, according to project.
Motor generator, D. C.–A. C., 2 to each casemate.
Panels, power, 1 to each casemate.
Planting equipment for emergency vessels, 1 to each vessel:

Each planting equipment consists of—

1 axle, cable-reel.
4 blocks, snatch.
4 blocks, triplex, 2-ton.
2 come-alongs.
2 davits, anchor.
2 davits, mine.
1 frame, cable-reel.
4 hooks, trip.

Plugs, compound, 1 to each mine case.
Reels, cable, according to cable on hand.
Reel and frame, measuring, 1 to each mine field.
Shackles, anchor, 2 to each anchor.
Shackles, mine, 2 to each mine.
Sister hooks, 1 pair to each anchor.
Sockets, mooring, 2 to each buoyant mine, for wire rope only.
Springs, automatic anchor, 6 extra for each group of 19 mines.
Switches, starting, 1 to each motor generator, D. C.–A. C.
Telephones, boat, 4 to each mine field.
Testing set, insulation, 1 to each post having a cable tank:
    Each testing set consists of—
        1 box, resistance, 100,000 ohms.
        2 cases for instruments.
        1 galvanometer, D'Arsonval, reflecting.
        1 key, special insulation testing.
        1 repair kit.
        1 shunt, Ayrton Universal.
Transformer, casemate, 2 to each casemate.
Transformer, mine, 1 to each mine.
Voltmeter, portable, 0–3-volt scale, 1 to each storage battery.
Voltmeter, portable, 0–150-volt scale, 2 to each post.
Weights, distance, for automatic anchor, 6 extra for each group of 19 mines.

UTENSILS.

(Supply for each post, unless otherwise indicated.)

1 anvil, 50-pound.
3 axes, handled.
6 basins, wash.
24 binding posts (to each casemate).
2 blocks, tackle, double.
2 blocks, tackle, single.
6 boxes, tool.
6 brushes, battery.
6 brushes, dust.
6 brushes, paint, flat.
6 brushes, paint, oval.
12 brushes, sash.
12 brushes, scratch.
6 buckets, galvanized iron.
1 chest, carpenter's tool:
    The chest contains the following tools—
        1 bits, set, of 13.
        1 bit, expansive,
        1 brace, ratchet.
        1 chisels, carpenter's, set of 6.

1 chest, carpenter's tool—Continued.
The chest contains the following tools—Continued.
1 hammer, claw.
1 knife, drawing.
1 level, carpenter's.
1 oilstone.
1 plane, jack.
1 plane, smooth.
1 rule, 2-foot.
1 saw, compass.
1 saw, hand.
1 saw, rip.
1 saw set.
1 square, carpenter's.
6 chisels, cold.
4 clips, wire rope (for each buoyant mine).
4 coppers, soldering.
3 crowbars.
6 cups, drinking.
2 cutters, cable.
1 dies, letters, set.
1 dies, numbers, set.
1 drill, breast.
1 drill points, set of 15.
6 files, 6-inch, flat bastard.
3 files, 6-inch, slim taper.
6 funnels, loading, large.
6 funnels, loading, small.
1 gloves, rubber, pair (to each storage battery).
1 grindstone.
24 hacksaw blades.
4 hacksaw frames.
6 hammers, ball peen.
6 hammers, smith's.
2 handles, with tools.
3 hatchets.
6 hooks, boat.
2 hydrometers, battery (to each storage battery).
3 irons, calking.
4 irons, grappling.
120 knives, submarine mine (for each mine company, to be issued as part of equipment).
3 ladles.
6 lamps, alcohol.
2 lamps, battery inspection (to each storage battery).
3 lamps, Khotal.
5 leads, sounding.

12 levers for socket wrenches.
12 life buoys.
12 life-preservers.
2 mallets, large.
2 mallets, small.
12 marlinspikes.
6 megaphones.
1 oilers and tray, set (to each casemate).
12 padlocks, brass, with chain.
2 pitchers, acid (to each storage battery).
2 plates, earth.
70 pliers, side cutting, 5½ inch (for each mine company, to be issued as part of equipment).
50 pliers, side cutting, 8-inch (for each mine company, to be issued as part of equipment).
3 pots, melting.
4 pumps, boat (to each mine field).
2 scales, extension spring, reading 200 pounds.
1 scales, portable platform.
6 scissors, 8-inch.
6 scoops, large, for trotol only.
6 scoops, small, for trotol only.
12 scrapers, iron, with handle.
4 screw-drivers, large.
4 screw-drivers, medium.
4 screw-drivers, small.
6 switches, assorted (to each casemate).
2 syringes, battery (to each storage battery).
3 tapes, measuring.
2 thermometers, battery (to each storage battery).
2 thermometers, cable tank.
2 thimbles, galvanized iron (to each buoyant mine case).
2 tongs, cable reel.
6 torches, gasoline, hand.
2 trucks, mine case.
6 vises, bench, large.
6 wrenches, monkey, 8-inch.
6 wrenches, monkey, 15-inch.
12 wrenches, S.
6 wrenches, socket.
6 wrenches, spanner.
3 wrenches, Stillson.
6 wrenches, T, small.

EXPENDABLE STORES.

Alcohol, wood, 5 gallons to each post.
Antimony for socket alloy, 10 pounds to each 19 mines.
Books, record of cable test, 1 to each post.

Books, daily test, 2 to each post.
Books, note, 24 to each post.
Brushes, carbon, 4 extra for each machine requiring them.
Brushes, wire, 4 extra for each machine requiring them.
Cells, dry, large, 25 to each post.
Cells, dry, small, 100 to each post.
Cement, rubber, 3 pounds to each 19 mines.
Cleats, porcelain, 1-wire, 50 to each casemate.
Cleats, porcelain, 2-wire, 50 to each casemate.
Collars, Turk's-head, large, 10 to each mile of 7-conductor cable.
Collars, Turk's-head, medium, 10 to each mile of 19-conductor cable.
Collars, Turk's-head, small, 5 to each mine.
Compound, commutator, 1 stick to each casemate.
Connectors, double, 25 to each casemate.
Cords, telephone, 4 extra.
Crayons, marking, 12 to each storehouse.
Cut-outs, porcelain, 2 to each casemate.
Drier, as required.
Electrolyte, specific gravity 1210, 4 carboys to each casemate.
Explosive, according to project.
Fuses, service, 4 to each mine.
Gasoline, for torches, 10 gallons to each post.
Glands for compound plugs, 2 extra for each plug.
Glue, 5 pounds to each post.
Graphite, as required.
Handles, assorted, as required for repairing tools.
Insulators, glass, 25 to each storehouse.
Jointers, copper, 1 pound to each 19 mines.
Keys, distribution box, flat, 4 extra to each box.
Keys, distribution box, split, 4 extra to each box.
Keys, mine case, 2 extra for each mine case.
Keys, shackle, 1 extra to each shackle.
Knobs, porcelain, 100 to each post.
Lampblack, 2 pounds to each 100 pounds of white lead.
Lamps, incandescent, white, 110 volts, 16-candlepower, 12 to each casemate.
Lamps, incandescent, white, 80 volts, 16-candlepower, 12 to each casemate.
Lamps, incandescent, red, 80 volts, 8-candlepower, 3 to each operating board.
Lamps, incandescent, green, 45 volts, 8-candlepower, 3 to each operating board.
Lamps, incandescent, green, 45 volts, 16-candlepower, 3 to each operating board.
Lamps, incandescent, green, 45 volts, 32-candlepower, 3 to each operating board.
Lead, for socket alloy, 90 pounds for each 19 mines.

Lead, red, as required.
Lead, white, as required.
Line, cod, 2,000 feet to each post.
Line, measuring, 2,000 feet to each post.
Line, sounding, 500 feet to each post.
Lye, as required.
Marline, 1 pound to each mine.
Nails, assorted sizes, 25 pounds to each post.
Needles, cleaning, for Khotal lamps, 6 to each post.
Nipples, soft rubber, 1 to each hard-rubber fuze can.
Oakum, 50 pounds to each post.
Oil, cylinder, 5 gallons to each casemate.
Oil, dynamo, 1 gallon to each casemate.
Oil, lubricating, 1 gallon to each storehouse.
Oil, linseed, as required, 3 gallons to 100 pounds of lead.
Oil, slushing, 5 gallons to each post.
Oil, tar, as required for marline-covered rope.
Oil, transformer, 1 gallon to each casemate transformer.
Packing, asbestos sheet, 2 pounds to each casemate.
Packing, asbestos wick, 1 pound to each casemate.
Packings, rubber, 100 to each 19 mines.
Paint, acid-resisting, as required.
Paint, steel color, for casemate apparatus, as required.
Paste, soldering, 1 pound to each post.
Paraffin, 10 pounds to each post.
Pencils, lead, 6 dozen to each post.
Plugs, attachment, 6 to each post.
Pomade, Putz, 3 pounds to each post.
Primers, explosive, 1 to each mine charge.
Pumice stone, 2 pounds to each casemate.
Resin, 2 pounds to each post.
Rope, for distance weight, 20 feet for each automatic anchor.
Rope for heaving lines, 1,200 feet to each post.
Rope for lashings, 1,200 feet to each post.
Rope, marline covered, according to project.
Rope, raising, 50 per cent more than of mooring rope.
Rope, wire-mooring, according to project.
Rosettes, 24 to each post.
Ruberine, 5 gallons to each post.
Sandpaper, 48 sheets to each post.
Sapolio, 10 cakes to each post.
Screws, brass, assorted sizes, 1 gross when required.
Screws, iron, assorted sizes, 1 gross when required.
Screws, set, for compound plugs, 1 extra set for each compound plug.
Screws, set, for mine transformers, 1 extra set for each mine transformer.

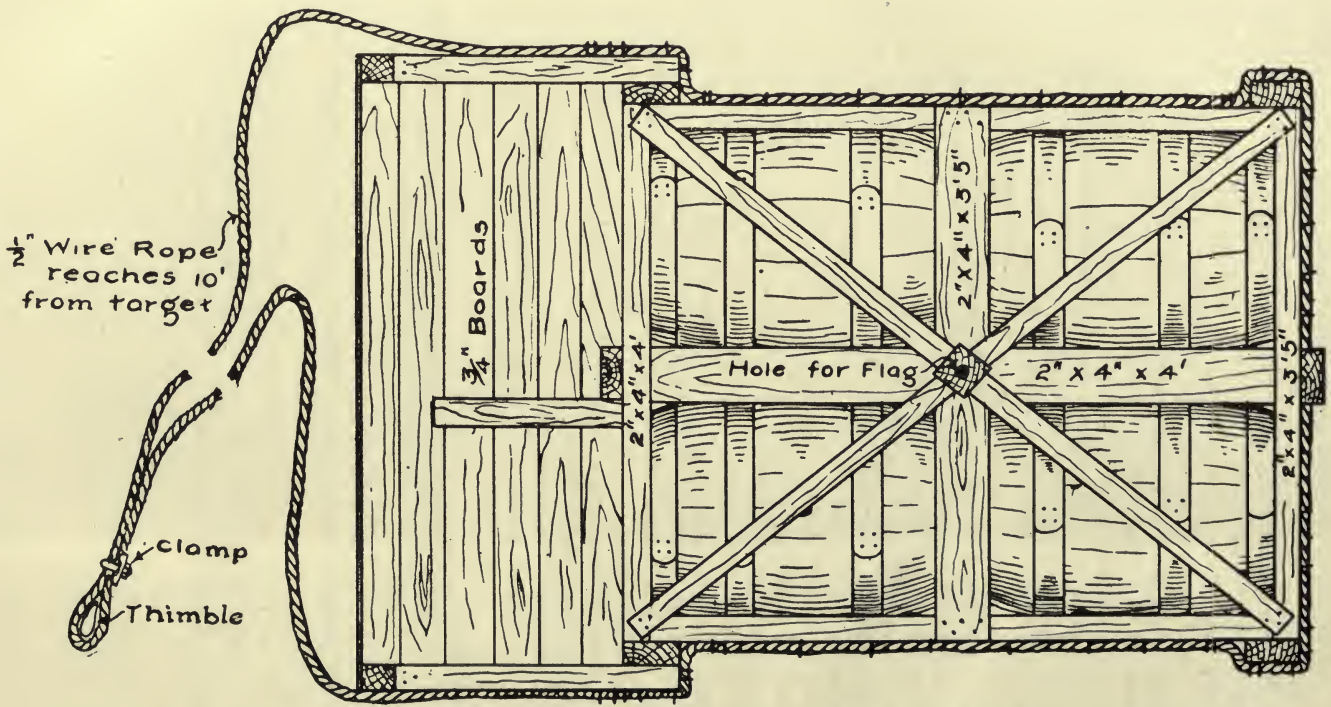
Shellac for insulation purposes, 5 pounds to each post.
Soap, 25 cakes to each post.
Sockets, lamp, 12 to each casemate.
Solder, wire, 5 pounds to each post.
Staples, large, 20 pounds to each post.
Staples, small, 1 pound to each post.
Suspensions, galvanometer, lower, 3 to each insulation testing set.
Suspensions, galvanometer, upper, 6 to each insulation testing set.
Tags, brass, 50 per group of 19 mines.
Tags, lead, 50 per group of 19 mines.
Tags, linen, 50 per group of 19 mines.
Tape, protective, 5 pounds to each 19 mines.
Tape, rubber, 5 pounds to each 19 mines.
Tinfoil, 1 pound to each 19 mines.
Towelling, 10 yards to each post.
Tubes, porcelain, 12 to each post.
Turpentine, as required.
Twine, 3 pounds to each 19 mines.
Varnish, asphaltum, as required.
Varnish, spar, as required.
Washers, brass, 100 to each 19 mines.
Washers, lead, 1 extra set for each compound plug.
Waste, cotton, 50 pounds to each post.
Wire, casemate, extra, 100 feet each of black, blue, red, and brown to each casemate.
Wire, fuse, 1 pound each of 3, 12, and 25 ampere to each casemate.
Wire, lamp-cord, extra 100 feet to each casemate.
Wire, loading, 20 feet to each mine.
Wire, soft drawn copper.

Remarks:

(*a*) Clips and thimbles, scales, extension spring, marline-covered rope, and parts for automatic anchors are required only at posts supplied with automatic anchors.

(*b*) Loading scoops are required only at posts supplied with trotol.

(*c*) In the case of articles to be supplied "as required" it is not contemplated that they shall be kept on hand in larger quantities than required for immediate needs.



Plan.

FIG. 17a.—IMPROVISED MINE TARGET.

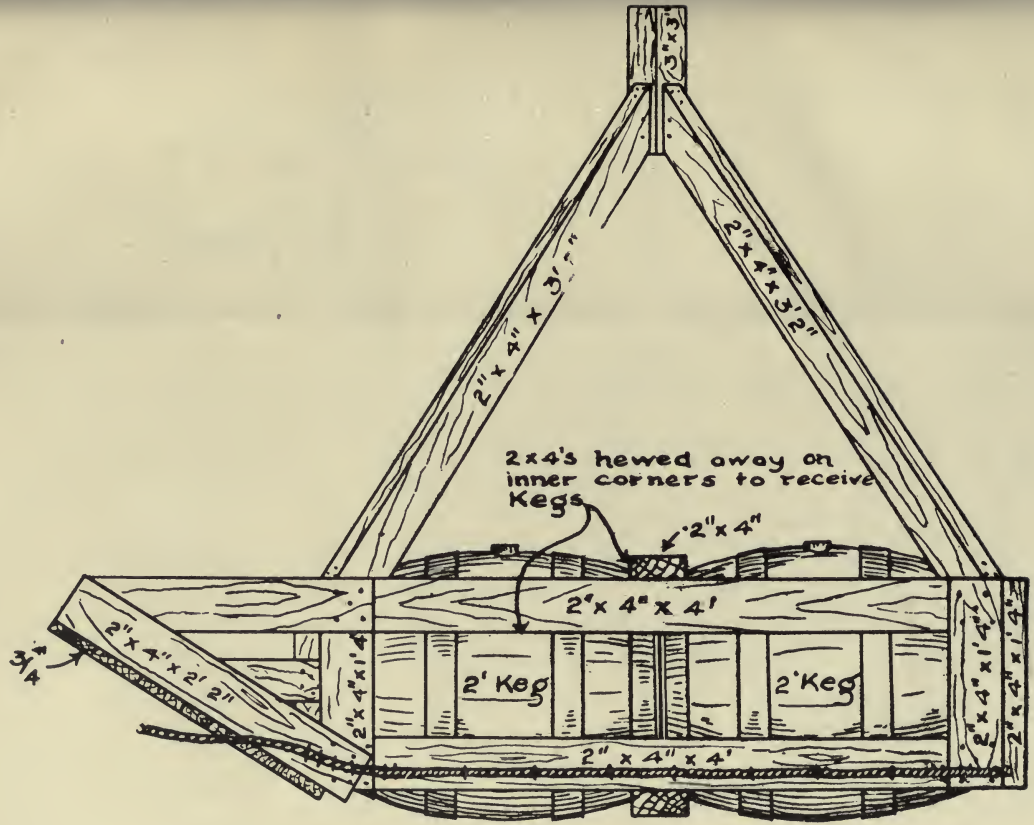


FIG. 17b.—IMPROVISED MINE TARGET.

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